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Health and r.f. radiation

THE possible hazards to health from intense radio-frequency radiation first came to public notice in the United Kingdom in 1958, when the Secretary of State for Air and the Postmaster General were asked in the House of Commons about possible hazards from radio stations using the forward-scatter technique. The replies emphasized that there was no danger to the public from any existing stations of this type. In April 1960 the Postmaster General announced in Parliament that he had received the report of the interdepartmental committee that had been considering safety precautions with intense radio-frequency radiation.

The recommendations of the committee are discussed in the Foreword on p. 267. The cover illustration this month depicts a typical aerial system used for tropospheric forward-scatter radio links

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JOURNAL

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SAFETY AND INTENSE R.F. RADIATION

In recent years the maximum transmitter power employed in microwave radar and radiocommunication equipment has steadily increased and has reached a level where danger to human and animal health may arise unless suitable safety precautions are observed. Public attention was called to this matter about a year ago by proposals to erect in the United Kingdom a small number of high-power tropospheric-scatter stations, and more recently by a proposal to establish a ballistic-missile early-warning radar station of exceptionally high power in Yorkshire. In both cases highly-directional aerials producing narrow beams of intense radiation are used, and it was stated that it would be necessary to exclude the public and unprotected persons from certain danger areas extending up to a mile or so in front of, and much shorter distances to the side of and behind, the aerials.

Although these cases of very-high-power transmitters served to focus public attention on the matter, it had been known for some time that some radio transmitters and other sources of radio-frequency radiation not in the highest-power category might nevertheless at short distances produce radiation intensities of a dangerous order.

In many countries, particularly in the United States of America, medical research has been and is being carried out on the biological effects of intense microwave radiation. Although this work is not complete, sufficient is known to enable maximum permissible radiation intensities and the necessary safety precautions to be established.

Recognizing that the problem was to some extent a general one, involving both civil and military radio and radar transmitters and some industrial r.f. equipment, the Government departments concerned set up a committee in November 1958 to consider the matter and to determine what safety precautions should be taken to safeguard members of the public, the operators at radio and radar stations, and the staff of research and industrial establishments. In carrying out its work the committee sought the advice of the Medical Research Council, the Service Ministries, the Department of Scientific and Industrial Research, the Ministry of Labour, the British Broadcasting Corporation, the Independent Television Authority, the trade associations and The Institution. Its report on 'Safety precautions relating to intense radio-frequency radiation' is to be published by H.M. Stationery Office.

On the advice of the Medical Research Council, the committee established, for radiation between 30 and 30000 Mc/s and for intermittent or continuous exposure, an upper permissible limit of radiation intensity of 10 mW/cm^2. (In the case of pulse-modulation systems the radiation should be averaged over complete trains of pulses, including intervals between pulse trains.) This limit is in conformity with that adopted in the United States.

Members of the public and unprotected persons responsible for the operation and maintenance of stations and equipment are to be excluded from areas where the radiation intensity exceeds the permissible limit, and suitable warning notices are to be displayed.

The dangers from intense radiation are mainly due to local bodily heating caused by the conversion of the electromagnetic energy of the radiation into heat energy; the most vulnerable parts of the body are stated to be the eyes and the testes. It is to be noted that the temperature-regulating mechanism of the body plays an important part. The smaller animals such as rabbits and dogs, which have less-effective temperature-regulating mechanisms, are more prone to thermal damage than human beings.

There is also some evidence to show that radiation intensities considerably above the permissible limit of 10 mW/cm^2 may produce other than thermal effects. The

extent and nature of these effects are not well understood, and further medical studies, including assessment of the results of long-term exposure, are needed. Cases of actual harm to human beings from intense radiation are very small in number, and the few established cases have involved intensities considerably in excess of the permissible limit referred to above.

Another aspect of the problem on which the medical evidence is incomplete concerns the frequency dependence of the maximum permissible limit of radiation intensity. For the present the limit of 10 mW/cm^2 applies to the whole range 30–30 000 Mc/s, although it is known that at frequencies below a few hundred megacycles per second the heating effects tend to be general rather than localized, and somewhat greater incident intensities may be permissible. Similarly, above a few thousand megacycles per second most of the radiation tends to be reflected and scattered from the surface of the body, and the remaining small proportion is absorbed just below the surface. In this case also, higher intensities may be tolerable.

A general specification for radiation-intensity measuring equipment has been prepared and is included in the document referred to above. In the preparation of this specification, allowance was made for the fact that, with certain designs of radar apparatus employing moving beams, the exposure is not continuous. To the extent that the main effects of intense radiation are thermal in character, it is permissible to average the radiation intensity. However, if the averaging is carried out over too long a period of time, unduly high maximum intensities may be encountered. In the absence of complete medical evidence on possible non-thermal effects, it has been thought advisable to choose a time-constant of one second for the indicating equipment, in order to limit the maximum intensity permitted in practice.

The development of radiation-measuring equipment has been sponsored by the Radio and Electrical Measurements Committee, Ministry of Aviation; until this equipment becomes available, application of the safety precautions will depend either on the use of laboratory field-strength measuring instruments or on calculation. Consideration is also being given to the design of protective clothing to be worn by operators and others likely to be exposed to radiation intensities exceeding the permissible level in the course of their duties.

The safety precautions described in the report will, in the case of the Government stations, be applied by the Government departments directly concerned; in the case of non-Government stations the granting of a licence will be conditional on an undertaking to observe the safety precautions.

The position in respect of industrial heating equipment is being reviewed by the Ministry of Labour, in co-operation with the committee. This apparatus produces very strong fields in its immediate vicinity, but the range is limited, so that little or no danger to the public is involved; the precautions necessary to protect operators are being examined. The field distributions in the immediate vicinity of such apparatus are complex, and a satisfactory measurement technique has yet to be evolved.

Finally, members of The Institution may wish to be reminded that a number of papers on the biological effects of intense microwave radiation, and the measuring equipment involved, are to be presented at the Third International Conference on Medical Electronics which is to take place at Olympia, London, from the 21st to 27th July 1960 (see April 1960 *Journal*, p. 200).

CO-ORDINATION OF TIME AND FREQUENCY TRANSMISSIONS

Early in 1960, co-ordination of the time and frequency transmissions of the United Kingdom and the United States was begun, and it is expected that by the end of the year the time signals from participating stations will be emitted in synchronism to a millisecond. The new co-ordinated service will be of great value in radiocommunication, geodesy, and the tracking of artificial satellites.

United Kingdom participants in the project are the Royal Greenwich Observatory, the National Physical Laboratory, and the Post Office Engineering Department; in the United States the U.S. Naval Observatory, the Naval Research Laboratory and the National Bureau of Standards are concerned. The transmitting stations are: GBR (Rugby), MSF (Rugby), WWV (Beltsville, Maryland), NBA (Canal Zone), and WWVH (Hawaii).

The carrier frequencies of the MSF and GBR transmitters are controlled by the same ring crystal oscillator and calibrated to an accuracy of 2 parts in 10^{10} by the N.P.L. caesium standard. The master oscillator also controls the time-signal dots of GBR and its associated short-wave transmitters. The master oscillators of the United States services will be adjusted to the same common standard agreed between the two observatories, and will be calibrated in terms of American caesium standards which are compared by radio with that of the N.P.L.

Time signals must be adjusted to give the standard of time commonly employed—G.M.T.—which is equivalent to the astronomical time U.T.2. However, since U.T.2 is subject to small unpredictable changes, measures of standard frequencies in terms of it will also vary. Towards the end of each year, therefore, the two observatories will assess the frequencies of U.S. and U.K. caesium standards, in terms of the current value of U.T.2 as fixed by astronomical observations, and use these to control transmitter frequencies and the 'rate' of time signals. Time signals will require adjustment perhaps twice a year.

621.3 : 378.2

Teaching electrical engineering in universities

Electrical engineering has been developing in a spectacular manner, mainly on account of new discoveries in physics. In this article, which is based on a part of the Chairman's Address delivered at Leeds before the North Midland Centre on the 6th October 1959, the author discusses the impact of these developments on teaching courses in universities.

Prof. G. W. CARTER, M.A., MEMBER

UNIVERSITIES as we know them first appeared in the Middle Ages, fulfilling the need of the society of that day for experts in philosophy, theology, medicine and law. In the intervening centuries they have changed greatly in response to changing social needs, and are developing still.

Social needs, however, affect different faculties and departments of the university in different ways, and it must by no means be taken for granted that conclusions which are valid concerning the study of medicine or chemistry, or even mechanical engineering, are also applicable to electrical engineering. There is therefore some value in examining the growth of electrical engineering as a single discipline, and in considering how it must be developed in the coming years if it is to be effective in serving the industry and the community.

The growth of electrical engineering as a separate discipline

Of all branches of engineering, electrical engineering is the least empirical, the most firmly grounded in experimental physics. There has been no place in its history for millwrights of genius, like James Brindley, the great canal-builder, who never learnt to read or write, or George Stephenson, who worked out elementary sums on his slate while he tended his engines. Electrical engineering could never have come into being without the experimental researches of men like Oersted, Ampère and Faraday, whose work even a self-taught genius like Edison had to master in some degree before he could make his contribution. Thus it came about that the earliest development of electrical engineering, namely telegraphy, was largely the work of physicists like Charles Wheatstone, who was Professor of Physics at King's College, London, and Lord Kelvin, Professor of Natural Philosophy in the University of Glasgow. For a time, indeed, it looked as if electrical engineering were to be almost synonymous with applied physics, and it might well have grown up as a university subject in this guise.

From about 1880 onwards, however, there began the immense development of electric power engineering, which revolutionized civilized life in a more far-reaching manner then either the telegraph or the infant telephone. Electric lighting in the home, electric tramcars in the streets, electric railways, electric motors in a thousand applications—these became for a time the main concern of the electrical engineer.

The electric power engineer, like the civil and the mechanical engineer, is dedicated to engineering in the sense described in the famous words of the Charter of The Institution of Civil Engineers, 'The art of directing the great sources of power in Nature for the use and convenience of man'. The power engineer, like the mechanical engineer, is concerned with the mechanical properties of materials, with friction, lubrication, ventilation, resistance to wear, critical speeds, and so forth. It was therefore quite natural that electrical engineering should have developed in the universities for the most part under the wing of mechanical engineering. Sometimes, as at Liverpool, there was a professor of electrical engineering from early days. More often we find the situation exemplified by Manchester, where Osborne Reynolds was 'Professor of Engineering' from 1868 (that is, before the incorporation of Manchester as a university), while the first separate 'Professor of Electrotechnics' was appointed in 1912; or by Leeds, which had a chair of engineering from its incorporation in 1904, but one of electrical engineering only from 1926.

Bias towards mechanical engineering

The kind of undergraduate degree course which grew up under these auspices—and which often did not change very rapidly even when electrical engineering was recognized as a separate discipline by the institution of a chair—was heavily biased towards mechanical engineering, especially in the earlier years. Much importance was attached to drawing-office work and to mechanical design; students were often called upon to carry out the design calculations for a whole series of electrical machines and to draw them in considerable detail. Courses of this general pattern persisted until quite recently. For example, at Leeds in the session 1946–47 the course for the honours degree in electrical engineering still contained more mechanical engineering than electrical. A student graduating at that time with honours in electrical engineering had spent, as a rule, 21% of his total class time (including laboratories) on electrical engineering proper, 23% on civil and mechanical engineering, 18% on drawing, 15% on mathematics and the remaining 23% on physics, chemistry, and other subjects.

Even if we think solely about the education of electric power engineers, this course seems somewhat unbalanced, and one suspects that the large content of mechanical engineering is mainly due to the fact that it got there first; the course is not a true electrical engineering one, but a mechanical engineering course modified in the electrical sense. However, much of the non-electrical material is at least quite relevant to the professional needs of an electric machine designer or power engineer. With some of that civil and mechanical engineering and drawing

cut out, there would be time for an extended treatment of electrical engineering, and the course, as a training for electric power engineers, would do very well.

Electronic engineering

We are concerned, however, not with a static industry, but with one which grows and develops like a living creature. As the professor of electrical engineering tries to keep his department abreast of this development, he feels as Alice did in Looking-Glass Land, when she had to run her hardest in order to keep in the same place. Physical discoveries capable of application to 'the use and convenience of man' did not cease with Faraday. The stream became broader year by year, bringing us the thermoelectric, photoelectric and piezoelectric effects, thermionic emission, electrical conduction in gases, non-linear resistance materials, ferrites, ferroelectrics, semiconducting materials—making possible new methods of measurement, communication, reproduction of sound, illumination, calculation, and who knows what? New mathematical techniques were called into being; ideas like energy transmission by waveguides, previously only known as theoretical possibilities, became realizable; sciences like control engineering, after many years of embryonic existence, grew up rapidly into their fruitful maturity.

All this had profound repercussions in the power-engineering field, as the mercury-arc rectifier drove out the rotary convertor, only to yield in its turn to the semiconducting rectifier; as electronic control circuits for industrial processes supplemented or superseded the panels of clattering contactors and relays; as new materials made possible greater power per unit, higher voltages and hotter conditions of operation. These changes, however, though far-reaching, are evolutionary; whereas the changes outside the power-engineering field are revolutionary. We have called into being a new kind of engineering, called electronic engineering, which has very little to do with 'the great sources of power in Nature'. When we reproduce Mozart on a loudspeaker or calculate π with a computer, the power consumed or transformed is only incidental to the main purpose. Electronic engineering breaks through the boundaries of the old definition of engineering, compelling us to re-define it as 'the art of directing the physical phenomena of Nature for the use and convenience of man.'

One discipline—or two?

This new and exuberant growth raises a fundamental problem. Is it now possible to regard electrical engineering as a single branch of engineering at all? Is electronic engineering inherently so different from electric power engineering that the two subjects are best treated as entirely distinct?

Many engineers would answer these questions affirmatively; and it must be admitted that they have some reason on their side, when one bears in mind the strong bias towards civil and mechanical engineering found in 'classical' electrical engineering courses. The electronic engineer who received his training in a course of this kind is inclined to snort with impatience at the thought of the time he spent on civil and mechanical engineering. 'Principles of design and construction of foundations, floors, walls, roofs, retaining walls, dams, roads, railways, bridges', says the syllabus. 'What use is all this stuff to an electronic engineer?' complains the victim, implying the answer 'None whatever', an answer which is perfectly correct. The fact is that the connection between electronic engineering and civil engineering is about as intimate as the connection between buttercups and butterscotch—they both contain the word 'butter'.

It is to be hoped that no one will defend foundations, floors, etc. with the plea that we must keep our education as broad as possible. If breadth means including irrelevant knowledge, there is the whole field of learning to choose from, and an electronic engineer might well derive more happiness from reading Virgil in his spare time than from designing gear profiles. But I believe that a university education should be based on a group of related and mutually relevant subjects, and that breadth should be imparted to an electronic engineering course by including plenty of electric power engineering, mathematics and physics, with economics and social history.

The unity of electrical engineering

I am strongly in favour of maintaining the unity of electrical engineering as far as is ever possible, even at the expense of slackening the traditional ties between electric power engineering on the one hand, and civil and mechanical engineering on the other. The same physical principles underlie both power and electronic engineering, though the relative importance of different factors may be changed; and there are many instances of a man being better equipped for one branch through his knowledge of the other. I have myself witnessed experience of surges in power cables being applied to the design of modulators for radar, and experience with power-frequency transformers to the design of pulse transformers. On the other hand the eddy-current loss in a machine core may be calculated by means of the Poynting vector, a concept more familiar to radio engineers; and the power engineer with a good knowledge of electronics will not be surprised if, in surge conditions, his coils exhibit capacitance and his capacitors inductance. Furthermore, some fruitful and developing parts of electrical engineering, notably control engineering, really constitute border territory between power and electronics. For reasons such as these, I believe that the future electronic engineer and the future power engineer should be made to follow the same path of study for a considerable time, though with some divergence and specialization at the end.

The trend of future development

To make possible a unified treatment of electrical engineering, one primary condition must be satisfied: namely, breaking away from the classical connection with mechanical engineering, and returning to the real foundation of electrical engineering, which is physics.

What, for example, is the ultimate value of a course in heat engines to a student of electrical engineering? Not, surely, that it puts him in the way of being able to design the 'steam end' as well as the 'electrical end' of a turbo-alternator; he is most unlikely to be called on to do this. Rather, that it introduces him to a set of fundamental principles—the principles of thermodynamics—which have a bearing on many of the problems arising in electrical engineering. Thus, the problem of heat transfer is crucial in the design of much power apparatus; the kinetic theory of gases lies behind the familiar phenomena of the conduction of electricity by metals, and behind the operation of innumerable thermionic devices; the distinction between reversible and irreversible processes is fundamental to any real understanding of the applications of physics. The electrical engineer's need for a knowledge of thermodynamics is most imperfectly met, however, by putting him through a course on heat engines; let it therefore be replaced by a course in applied thermodynamics, adapted to the special requirements of electrical engineering. In the same way, let the theory of machines, with its emphasis on kinematical problems of special interest to the mechanical engineer, be superseded by applied mechanics. Above all, let attention be paid to the physics of materials, for this underlies the whole of engineering. Developments of this sort are conspicuous in the United States, where much attention has lately been paid to rethinking the fundamentals of electrical engineering education, and where I believe that certain colleges have at this moment progressed beyond the point reached here.

The place of mathematics

Hand in hand with this increasing emphasis on physics, there must be an opportunity for the more capable students to advance far in mathematics, for which electrical engineering provides an almost limitless field of application. It is gratifying to find that many of our students are able to carry the study of this subject much beyond the point reached by their predecessors of ten years ago, and that they often acquire a firm belief in its value. It is my experience, however, that an argument from physical intuition is usually more satisfying to an engineer than a purely mathematical proof. Mathematics should therefore be taught to engineering students in a manner which associates it closely with the underlying physics of the problem, and in which the element of mere symbol-juggling is reduced to a minimum.

The mathematicians who have contributed so greatly to the development of electrical engineering have not been men who erected Eiffel Towers of symbols for the sake of their philosophical interest, as some of the modern exponents of machine and circuit theory appear to do. Rather they have worked in the true spirit of the engineer, namely with the intention and expectation of finding out something useful, and so contributing to 'the use and convenience of man'. It is this spirit which should infuse the teaching of mathematics, and indeed of all other subjects, to students of engineering; for engineering forms a bridge between the sciences and the humanities, since, though based on science, it traces the very purpose of its existence to an endeavour to satisfy human needs.

Summary

The growth of electronic engineering has brought university departments of electrical engineering to a point of decision. Either they must acquiesce in the division of electrical engineering into two disciplines, power engineering and electronics; or they must think afresh about the basis of an electrical engineering course, breaking away from the traditional association with mechanical engineering and moving closer to physics. The author is strongly in favour of the latter alternative.

ANNUAL DINNER OF THE ADMIRALTY ELECTRICAL ENGINEERING OFFICERS

THE Annual Dinner of the Admiralty Electrical Engineering Officers was held in Bath on the 8th March 1960. Sir Hamish MacLaren, Director of Electrical Engineering, Admiralty, presided. Mr. H. Jackson, Chairman of the Western Centre, was present. The Third Sea Lord and Controller of the Navy, Admiral Sir Peter Reid, paid tribute to the notable contribution of the Admiralty Electrical Engineering Officers to the ships of the Royal Navy. He said that recent changes were already proving their worth and that the answers were emerging to the problem of how best to 'ensure the human element required to form the blend of civilian engineers and naval officers needed to do the job'.

Sir Hamish MacLaren, replying, said he hoped they would again attract the necessary numbers of young men of quality. He also referred to his impending retirement in October next and expressed his appreciation of the honour of having presided eight times at the dinner.

The guests included Councillor Arthur Mortimer, the Mayor of Bath; Mr. G. E. T. Nichols, the Chief Constable of Bath; Sir John G. Lang, Secretary of the Admiralty; Mr. A. J. Sims, Director General Ships; and Mr. J. J. Gracie, who responded to the toast of the guests proposed by Mr. E. A. Lennox, electrical engineering manager, H.M. Dockyard, Portsmouth.

Dounreay fast reactor

THE first series of experiments having been completed, the fast-breeder reactor at Dounreay has been closed down for a few months while changes are made to the core to permit a wider variety of fuels to be tested.

Since it started low-power operation in November 1959 the reactor has provided data for operation at higher power levels and for the design of a fast-breeder reactor prototype.

AIRCRAFT ELECTRICAL ENGINEERING

621.3 : 629.13

The Bristol 188, a supersonic research aircraft made of stainless steel

After a discussion of the basic requirements for aircraft electrical equipment, this article dwells briefly on the development of generation equipment and on the increasing use of semiconductors, and the author predicts trends in future aircraft. Dr. Flack is with Bristol Aircraft Ltd.

D. C. FLACK, B.SC.(ENG.), PH.D., MEMBER

An aircraft electrical system is a complete generation, distribution and utilization system and in a large transport aircraft is of similar electrical size to that of a small town. You may expect to find a generation capacity of 200 or 300 kW, a distribution system involving 30–40 miles of cable, and utilization equipment including one or two hundred electric motors, heating loads for de-icing and domestic purposes, as well as radio and complex navigation and control equipment.

Aircraft electrical engineering is based, like all other branches of engineering, on economic considerations. These however have vastly different values which are associated particularly with the weight of the equipment, and it is in this respect that it is so obviously different from other electrical equipment. In addition the arduous environmental conditions sometimes introduce peculiarities into the equipment.

Weight

The two conflicting requirements that are the basis of aircraft equipment are that it shall be of minimum weight and maximum reliability. Consider first the weight of equipment, for this is fairly easily expressed in terms of money in the case of a civil transport. It must obviously be similar for military aircraft, but it is not easy to relate the value of dropping a bomb in the right place to pounds, shillings and pence.

If you make the following assumptions:

(i) that 1 lb weight is removed from the basic weight of an aircraft and added to the payload so that the 'all-up weight' remains unchanged

(ii) that the additional payload capacity is utilized for 50% of the flying life of the aircraft

(iii) that the aircraft achieves 3000 hours' utilization per annum

(iv) that the block speed is 300 m.p.h.

(v) that the revenue is at the rate of 10s. per ton-mile of payload carried

then the revenue per annum for the 1 lb of payload is:

$$1 \times \tfrac{1}{2} \times 3000 \times 300 \times \frac{10}{20} \times \frac{1}{2240}$$

or £100.

If a component lasts for more than one year, or if a number of similar components are used on one aircraft, this figure is increased in proportion. Alternatively, money spent on the design and development of a component is returned manifold if it is used in a number of aircraft.

Apart from the obvious need to use the lightest possible materials, the weight of electrical components is kept low by high electrical, magnetic, and mechanical loading, and as a result the losses for a given volume are relatively high. The problems associated with the generation of heat in a small volume are usually the limiting factors in the design of equipment, and these are tackled in the following ways:

(i) by using materials which will withstand high temperatures. The limit is usually set by insulating materials. Aircraft cables are continuously rated at 105°C, and winding hot-spots of 170°C are not uncommon

(ii) by the use of short time ratings. The loading in a surprising amount of utilization equipment can be increased in this way. Damage which may be caused by abnormally frequent operation can be prevented by a matched thermal circuit-breaker or an embedded thermal switch

(iii) by blast cooling continuously rated components. Fan cooling is restricted to applications in which there is a small range of ambient pressure, that is in pressurized or low-flying aircraft. Ram-air cooling varies with speed and must be augmented in some way if the equipment is to be used on the ground.

Reliability

Reliability as applied to aircraft electrical services has two senses, one which is associated with the safety of the aircraft, and the other which has, as an aim, the reduction in component unserviceability and maintenance costs. These two are in some ways contradictory.

Consider a complete electrical utilization service which, together with all its components, has a reliability of one failure in 1000 flying hours. If average flight duration is, say, 5 hours, there will be a failure rate of one in 200 flights. For all but the few unimportant circuits this reliability would not be sufficient and the designer has two choices immediately available to him.

Both safety and component reliability can be increased by reducing the electrical and mechanical stress in the components. This however has to be paid for in weight, and the law of diminishing returns applies forcibly if this is taken very far. On the other hand, increased safety reliability alone can be achieved by duplication of either individual components or complete circuits.

If a complete duplicate circuit is installed, having the same failure rate as the primary circuit in the above example, the service would be lost, on average, once in 40000 flights. If the particular service were such that the aircraft was made appreciably less safe by its loss, then a greater reliability, perhaps by triplication, would be required.

By this choice, however, the number of components has been increased two or three times, and the over-all component failure rate has therefore also been increased. The fact that the failure rate has been increased in proportion, whereas the safety has been increased exponentially, may appear to be a fair exchange. This has been the tendency in modern design and has undoubtedly resulted in safer aircraft. It has, however, proportionally increased the maintenance costs and delayed departures, since to keep this higher standard of safety all services must be fully operative before flight.

The cost of passenger criticism and also accommodation if the delay is considerable cannot be overemphasized and, together with the direct maintenance costs, has already become a major consideration of airline operators. The number of departures which are delayed by technical faults approaches 10% in modern airliners. The reduction in the number of engine defects which has resulted from the change from piston to turbine engines has unfortunately been more than offset by the growing complexity of the various systems.

This leads to a third, and all too obvious, step towards the improvement of reliability: the components and circuits in aircraft should be reduced in complexity. Aircraft electrical engineers, like all good engineers, should have this as a primary aim, but they are confronted with the ever-increasing demands of higher-performance aircraft and they are limited by the techniques which are available at the time. Undoubtedly the development of aircraft since the Second World War and their demands for precise automatic controls of the various services have increased at a higher rate than the techniques of the component manufacturers.

If this is a criticism of the component manufacturers, it applies equally to the aircraft constructors, since they have not always indicated the shape of their future developments. Furthermore, they have been reluctant to adopt new systems that have been offered, for example a.c. generation and distribution which was first developed in this country. This has unfortunately resulted in the tendency for American components to be of a more advanced design than ours, and the tendency for the adoption of these American designs for the British aircraft which are now on the drawing-boards.

The majority of failures are mechanical rather than electrical, and although this may be 'the nature of things' it might also be a criticism of the basic mechanical-engineering ability of the electrical engineers employed in the aircraft constructing and equipment industries.

The trends in the design of aircraft electrical systems which will be encouraged by the electrical designer, as opposed to those which are forced on him by the increasing requirements of the aircraft, will be towards greater reliability, and it seems to me that this can be achieved only by making use of devices which are more 'electrical' and less 'mechanical'.

Environmental conditions

Other design peculiarities of aircraft electrical equipment result from the extreme variations of atmospheric conditions. Equipment on a modern high-altitude aircraft may have to withstand an ambient temperature range of about $+50°$ to $-70°$C, often during the same flight. It must work satisfactorily in the rarefied atmosphere, and this has a direct bearing on switchgear and commutator design and on brush wear. As far as cooling of equipment is concerned, the fall in temperature with altitude more than compensates for the fall in pressure up to about 40000ft, but above this height the cooling problem becomes increasingly severe.

Condensation in world regions of high humidity presents its problems just as with normal ground-based equipment, but a particularly severe condition arises when an aircraft which has been flying for a long period at altitude in an ambient temperature of, say, $-60°$C descends through clouds to make a landing. Equipment which has no self-heating, for example an unenergized contactor, can build up ice, and if this deposits on the contacts it may result in a malfunction.

The aircraft itself contributes to the adverse environmental conditions. If equipment is mounted near the engines, vibration levels equivalent to an acceleration of $30g$ are common, and for engine-mounted items these are often exceeded. In the fuselage, vibration levels are a good deal less, but care must be taken in equipment design so that resonance is not caused, because the natural frequency of some components is the same as predominant frequencies of the aircraft structure. Equipment must also be designed to withstand linear accelerations. These are not normally more than $3g$ in civil

aircraft but can be as high as 9*g* in aerobatic or military aircraft.

Choice of supply

The choice of system voltage tends to be dictated mainly by the distribution system, the larger aircraft and larger powers requiring the higher voltages. On the other hand the choice between a.c. and d.c. is settled basically by the utilization equipment, although this is biased by any difficulties associated with generation.

Up to the end of the recent war, utilization equipment required only 28 volts d.c., any requirement for a higher voltage in such equipment as radio being satisfied by a motor-generator within the equipment. As power demands grew rapidly after the war, higher-voltage d.c. was tried (112 and 120 volts). With these higher powers, and also higher-altitude flight, the conventional d.c. generator was replaced by an alternator and static rectifier. This allowed heating loads, particularly for de-icing, to be taken direct from the alternator, thus economizing on the duty of the rectifier.

Although this system offered relative simplicity it did not satisfy directly the ever-increasing demands of loads for constant-frequency a.c., and all aircraft started to collect more and more inverters. These are usually d.c. motor-alternator sets, not true inverters, and are both heavy and inefficient.

It is the nature of these inverters, more than anything else, which has encouraged the development of 400c/s constant-frequency main generation, and although this offers many advantages to the electrical system it is not without its troubles on the mechanical side. A large number of ways of obtaining a constant-speed drive have been proposed, and the popular ones are discussed in detail in the proceedings of the Institution convention on aircraft electrical equipment which was held in May 1956.*

Various mechanical infinitely-variable gears based essentially on friction have never found much favour. Straight hydraulic drives using an engine-driven pump and hydraulic motor have been used only in the smallest applications owing to their weight and inefficiency. An adaptation of this is the hydromechanical drive which operates like a differential gearbox. The main power is passed through the drive from the engine to the alternator, and a hydraulic motor is placed at the third limb and makes up the difference speed. The great advantage of this is that the hydraulic circuit provides only the difference power and, if the engine gearing is correctly chosen, this power is at a minimum at the normal cruising speed of the engine. This type of drive is probably the most popular, and is in service.

With the universal introduction of turbine engines in high-performance aircraft, auxiliary power is available from air bled from the engine compressor. In its simplest form, this air is used to drive an air turbine, and this provides a drive with the least installed weight, although the efficiency reflected in engine fuel consumption is usually bad and the over-all weight is relatively high except for aircraft of short flight duration. In an attempt to make use of this simple and reliable power source in a more efficient way, mechanical differential drives similar to the hydromechanical drives are becoming available, in which the hydraulic motor is replaced by an air motor.

In aircraft which fly at supersonic speeds the use of ram air for driving an air turbine may offer an efficiency advantage. This has to be used in association with an engine-bleed air turbine to provide power at subsonic speeds.

Auxiliary power units involving the use of entirely separate engines as alternator prime movers have been reviewed with varying enthusiasm since the Second World War. They have, in general, a low power-to-weight ratio and have a higher specific fuel consumption than the main engines. The total installed weight, however, cannot be set against the electrical system since the total power on the aircraft has been increased: that is, the payload can be increased, or perhaps a better way of expressing it is that the auxiliary power unit partially carries its own weight. The main disadvantage is that the decrease in engine power with altitude will not normally match the alternator load requirements. The increasing power demands when the aircraft is on the ground point to the use of an auxiliary power unit in this régime, and this might influence the main generation system.

The coming of the semiconductor

All engineers should be quick to take advantage of new inventions and discoveries, and this applies particularly in aircraft circles, where the economic values are such that investigation and development can be well rewarded. The most important advance in electrical engineering for a considerable time, and one which has already started to make its impact on aircraft, is the semiconductor in its various forms.

The increasing use of transistors in radio and navigation equipment, and the changeover from magnetic amplifiers in control equipment, are largely removing those items which set the pace in the demands for constant-frequency supply; they are now tending towards a d.c. supply. At the same time the transistor inverter is basically such a reliable component that the loads such as radar, gyroscope motors and certain instruments, which still demand controlled frequency, can be supplied through these power packs in a relatively light-weight and efficient way. Because of their reliability they may well be built into utilization equipment and result in a d.c. demand only.

Fig. 1 shows a comparison between a 150VA motor inverter and a 225VA transistor inverter. The latter has a lighter specific weight as well as superior output characteristics.

Thus the loads which originally set the requirement for constant-frequency a.c. are swinging back to d.c. As the size and number of continuously running motors have increased there has been a keen desire to use induction motors rather than d.c. motors, for the same

* *Proceedings I.E.E.*, 1956, 103 A, Suppl. 1

reasons that led to the use of alternators in place of d.c. generators, and they are now the only real customer for the constant-frequency a.c. supply.

Although induction motors are not essentially constant-frequency loads, it seems that they alone will dictate the choice of a constant-frequency generation system in future aircraft. Depending on the frequency range of a direct-driven alternator and the total power of induction motors involved, the simplicity of such a system must be set against the increased weight and size of the machines.

1 *Comparison of a motor inverter (left) and a transistor inverter (right)*

In any case the future of the engine-driven constant-speed drive seems to be limited by the promise of the transistor frequency-changer. This takes 'frequency-wild' power from a direct-driven alternator and converts it to the frequency required. Such power that is required for de-icing and heating loads can of course be taken direct, and, while the over-all weight may show a disadvantage when compared with the constant-speed drive, it will certainly be far superior from the point of view of reliability.

There is little doubt in the minds of aircraft constructors and operators that relays and switchgear in general give more than their fair share of trouble. It may be in this direction that the semiconductor in the form of the controlled diode can offer the biggest reward in reliability. In this role it also promises a considerable weight advantage. Small diode switches are finding their way into aircraft and will undoubtedly be used in larger numbers, and in the larger powers which are becoming available.

Looking further into the future, several methods of generation of electrical energy can be seen in the hands of the pure research worker, and the one which appears to offer the greatest advantage to the aircraft electrical engineer is the thermoelectric generator. Considerable research work has been done on thermopiles constructed of semiconductor material such as lead telluride. Hot-end temperatures above 600° C have been used and conversion efficiencies better than 10% have been achieved. While this does not compare too well with the over-all efficiency of a direct-driven alternator which might approach 30%, it does show up well against an air-turbine drive with an efficiency more like 5%. The immediate thought is that this material could be wrapped around the outlet pipe of a jet engine, but it must be remembered that this heat is not waste. In fact it represents useful thrust of the engine, and its value is about the same as that of heat derived straight from fuel.

The disadvantage with a source of this type is that the available voltage varies with temperature, that is with engine power, and it also has a high internal resistance, giving bad regulation. It appears that the best way of using such d.c. power is to convert it to a.c. in a transistor convertor and control the voltage at the output. Thus for the first time in aircraft, and in other applications for that matter, we shall be generating d.c. and converting it to a.c.

The alternator

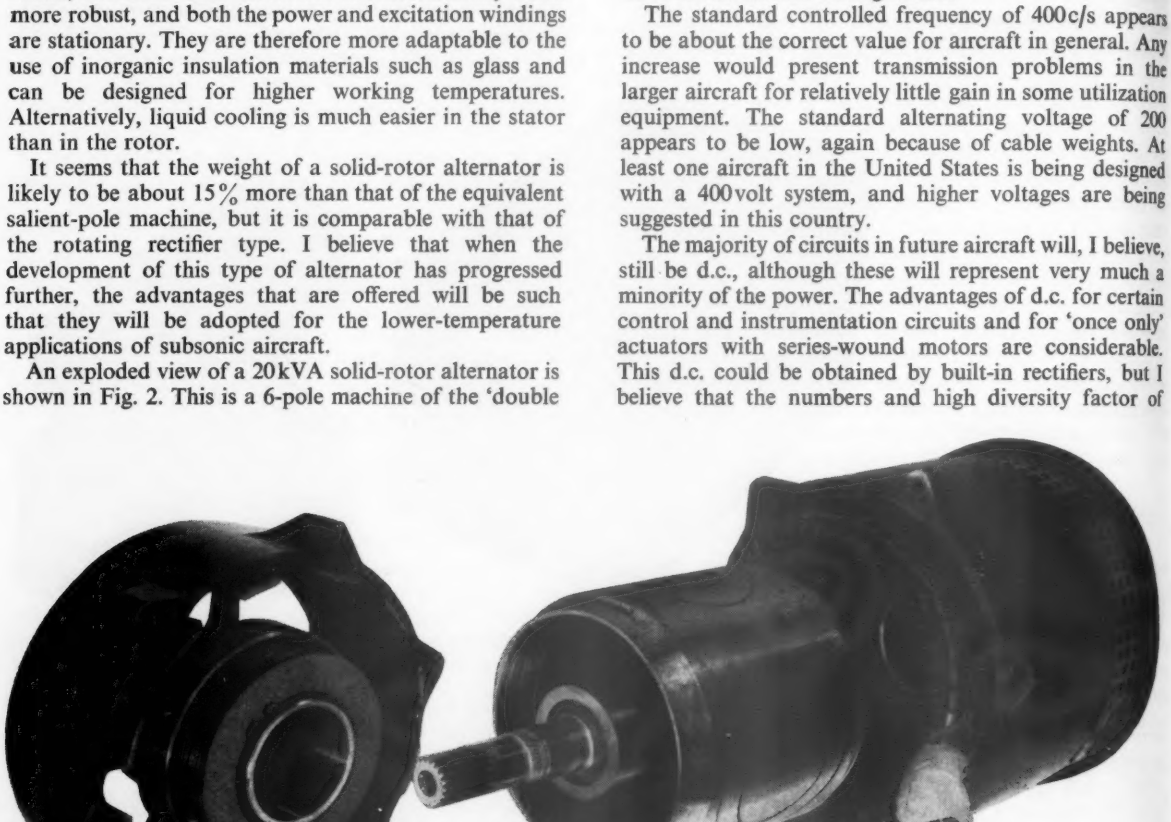
Whereas the step from the d.c. generator to the alternator took more time than it should have taken, the subsequent development of the alternator has been rapid. The conventional salient-pole alternator is very similar to its ground-based equivalent, except of course in size and weight, and has been produced generally as a 6-pole machine (8000 r.p.m.) in England and an 8-pole machine (6000 r.p.m.) in the United States. The tendency is now towards removing the slip rings and their associated

brush-wear troubles by means of a built-on exciter in which the commutator is replaced by rotating silicon rectifiers, the exciter armature power being fed directly into the main rotor windings.

Mainly owing to the high temperatures met at supersonic speeds, there is now pressure on the development of solid-steel-rotor alternators. They are of several forms, but in all cases the rotors are mechanically much more robust, and both the power and excitation windings are stationary. They are therefore more adaptable to the use of inorganic insulation materials such as glass and can be designed for higher working temperatures. Alternatively, liquid cooling is much easier in the stator than in the rotor.

It seems that the weight of a solid-rotor alternator is likely to be about 15% more than that of the equivalent salient-pole machine, but it is comparable with that of the rotating rectifier type. I believe that when the development of this type of alternator has progressed further, the advantages that are offered will be such that they will be adopted for the lower-temperature applications of subsonic aircraft.

An exploded view of a 20kVA solid-rotor alternator is shown in Fig. 2. This is a 6-pole machine of the 'double Lundell' type. The two excitation coils can be seen, one inside the stator and the other attached to the end frame. The three circular poles are of one polarity, the remainder of the rotor providing the alternative poles, and the annular rings between the two being non-magnetic.



2 *A 20kVA solid-rotor alternator*

The next 'breed' of aircraft

It would appear that in all future aircraft except the small low-performance types, primary generation will be by means of alternators, and I believe these will be solid-rotor machines. The percentage of the load represented by a.c. motors will be the main factor in the choice between a wild-frequency or constant-frequency system, and if this is considerable the choice may well be between a direct engine-driven alternator with a transistor frequency-changer, or by constant-speed auxiliary power units or air-turbine arrangements.

The standard controlled frequency of 400c/s appears to be about the correct value for aircraft in general. Any increase would present transmission problems in the larger aircraft for relatively little gain in some utilization equipment. The standard alternating voltage of 200 appears to be low, again because of cable weights. At least one aircraft in the United States is being designed with a 400volt system, and higher voltages are being suggested in this country.

The majority of circuits in future aircraft will, I believe, still be d.c., although these will represent very much a minority of the power. The advantages of d.c. for certain control and instrumentation circuits and for 'once only' actuators with series-wound motors are considerable. This d.c. could be obtained by built-in rectifiers, but I believe that the numbers and high diversity factor of such loads will favour the retention of transformer rectifier units.

There is no doubt that the present standard of 28 volts d.c. is too low for economic use, even in present aircraft, and this will surely be so in future machines. On the other hand it appears that 112 volts presents commutation and winding difficulties on the small types of load which will use d.c. I believe that a good compromise might be 56 volts, but in view of the wide range of equipment already available for use on 28volt systems it seems unlikely that there will be any change.

The general trend of utilization equipment is unfortunately towards greater complication. This is dictated by the ever-increasing requirements of aircraft and not by any wish of the electrical engineer. There is little doubt that the future high-performance aircraft will demand precise control, and this seems to mean electrical control, of all its functions. Already aircraft in service have their engines, fuel, de-icing, and air-conditioning systems, and most of their instrumentation, controlled electrically. This is presently being extended to include all instruments and also the fundamental flying controls of the aircraft.

The high-performance aircraft of the future is likely to have nothing except electric cables between the pilot and his various services. This, in fact, becomes almost an essential with the requirement of fully automatic landing in which the autopilot, acting largely on radio information, lands the aircraft and brings it to a halt on the runway.

This is all made more difficult by the heating effect at high speeds. This is sometimes wrongly called a 'heat barrier' whereas it is in fact a progressive problem, the adiabatic temperature rise at the skin of the aircraft increasing as the square of its speed. Even at high altitude this represents a skin temperature of about 250°C at a speed three times that of sound. At about this temperature you meet a much more realistic barrier in electrical engineering, since it appears to be the limit of organic insulation materials, and, if this temperature is exceeded, inorganic materials, such as magnesium oxide insulation, are required for cables, and glass, mica, and ceramics for winding insulation.

The refrigeration plant in such an aircraft becomes extensive and the control of it both important and complicated. The problems of these new excursions do not appear to relieve the designer of existing problems at the other end of the scale. High-speed aircraft have to fly slowly at some time and have to descend through icing conditions to make a landing.

Whatever the precise direction of trends in aircraft electrical engineering, there is no doubt that the utilization of electricity in aircraft will increase both in power and complexity, and there will be a growing demand for qualified engineers. It is unfortunate that the outlook for the aircraft industry, as represented in the popular Press, is frightening away qualified engineers, whereas the demand for technical manpower in the industry has never decreased through its history. The demand for qualified electrical engineers has never been greater, and will undoubtedly increase.

Summary

The basic requirements of aircraft electrical engineering are low weight and high reliability. Weight is kept down by high loading of components. Reliability can be improved by the adoption of static components, particularly the semiconductor. A general simplification of equipment is largely opposed by the ever-increasing demands of higher-performance aircraft, but there is no doubt that brushless alternators and semiconductor devices such as switches will play their part in future aircraft.

Site studies of off-peak heating

OFF-PEAK electrical heating, as an aspect of intermittent heating, is one of the topics being studied, both theoretically and practically, by the Heating and Ventilating Research Association, whose new building at Bracknell, Berkshire, was opened by Lord Hailsham, Minister for Science, on the 6th April 1960.

A committee set up to go into criticisms made about the accuracy of design procedure for off-peak systems is expected to produce a report by the end of 1960. The association is concurrently conducting site studies in six buildings in Southern England, and laboratory experiments using numerical (finite-difference) methods.

In connection with intermittent heating, an electrical analogue, an *RC* network representing a building, has been constructed to investigate the thermal properties of building structures, and its use will be extended to automatic controls.

The work of the association comes under five headings: heating, ventilating and air conditioning, operations research, physical and chemical problems, and information services. Field investigations of intermittent heating have figured largely in the research programme since the association's beginnings, as a Research Council, late in 1955.

N.P.L. AUTONOMICS DIVISION

THE name of the Control Mechanisms and Electronics Division of the National Physical Laboratory at Teddington has been changed to Autonomics Division, it was announced recently.

The word 'autonomics', meaning 'self-governing', is thought to be particularly apt as a description of the new types of device that the Division aims to develop. The Division has already established a fine record in the field of automatic control and in pioneering digital computers, but, now that industry has adopted these techniques, research has moved forward into new spheres.

Existing machines are deterministic, in that their behaviour can be predicted from their design and their environment. Conversely, they can be designed only after a detailed mathematical analysis of the factors involved. By working closely with biologists in studying the methods which living physical systems use to achieve control, the Autonomics Division hopes to discover underlying principles on which machines which can improve their own performance can be built. The autonomic devices of the future will be self-governing machines which discover for themselves how to recognize, how to translate and how to control.

The Institution's Annual Dinner, 1960

The President and the chartered engineer

SOME 1480 members and guests attended the Annual Dinner of The Institution at Grosvenor House, London, on Thursday, 25th February 1960. The President, Sir Willis Jackson, D.SC., F.R.S., was in the chair.

The following were among those present:

The Rt. Hon. The Viscount Kilmuir, G.C.V.O. (*Lord Chancellor*); His Excellency Tunku Ya'acob, P.M.N., C.M.G. (*High Commissioner for the Federation of Malaya*); Sir Gilbert Rennie, G.B.E., K.C.M.G., M.C. (*High Commissioner for the Federation of Rhodesia and Nyasaland*); Herr Dr. Hans-Joachim Mangold (*Commercial Counsellor, representing the Ambassador for the Federal Republic of Germany*); Councillor Group-Capt. G. H. Pirie, C.B.E., J.P. (*The Rt. Worshipful Mayor of the City of Westminster*); Dr. the Rt. Hon. Charles Hill, M.P. (*Chancellor of the Duchy of Lancaster*): F. J. Erroll, M.P. (*Minister of State, Board of Trade*); Dame Mary Smieton, D.B.E. (*Permanent Secretary, Ministry of Education*); Sir George Thomson, M.A., LL.D., SC.D., F.R.S., NOBEL LAUREATE (*Faraday Medallist 1960; President, The Institute of Physics; President, The British Association for the Advancement of Science*); The Rt. Hon. The Viscount Chandos, D.S.O., M.C. (*President, The British Electrical Power Convention*); The Rt. Hon. The Viscount Falmouth; The Rt. Hon. The Viscount Simon, C.M.G. (*Chairman, Port of London Authority*); The Rt. Hon. Lord Nelson of Stafford (*Past-President*); The Rt. Hon. Lord Strathclyde (*Chairman, North of Scotland Hydro-Electric Board*); The Very Reverend E. S. Abbott, D.D. (*Dean of Westminster*); Sir Noel Ashbridge, B.SC.(ENG.) (*Past-President; Honorary Member*); Sir Ben Barnett, K.B.E., C.B., M.C., B.A. (*Chairman, Commonwealth Telecommunications Board*); Sir Harold Bishop, C.B.E., B.SC.(ENG.) (*Past-President*); Sir Leslie Gamage, M.C. (*President, The British Electrical and Allied Manufacturers' Association*); Sir Archibald J. Gill, B.SC.(ENG.) (*Past-President*); Sir Godfrey H. Ince, G.C.B., K.B.E., B.SC., LL.D. (*Chairman, Cable and Wireless Ltd.*); Sir Patrick Linstead, C.B.E., D.SC., F.R.S. (*Rector of the Imperial College of Science and Technology*); Sir Hamish MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC. (*Vice-President; Director of Electrical Engineering, Admiralty*); Sir George McNaughton (*Vice-President, The Institution of Civil Engineers*); Sir George Mallaby, K.C.M.G. (*First Commissioner, Civil Service Commission*); Sir Harry Melville, K.C.B., D.SC., LL.D., F.R.S. (*Secretary, Department of Scientific and Industrial Research*); Sir Steuart C. Mitchell, K.B.E., C.B.; Sir Keith Murray, B.SC., PH.D., M.A., B.LITT. (*Chairman, University Grants Committee*); Sir John Pickles, B.SC. (*Chairman, South of Scotland Electricity Board*); Sir Harry Pilkington (*Chairman, National Advisory Council on Education for Industry and Commerce*); Sir Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.) (*Past-President; Director General, Post Office*); Sir Harry Railing, D.ENG. (*Past-President; Honorary Member*); H. Desmond Carter (*President, The Institution of Mechanical Engineers*); S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (*Immediate Past-President*); W. K. Hutchison, C.B.E., B.A., B.SC. (*President, The Institution of Chemical Engineers*); W. G. Agnew, C.V.O. (*Clerk of the Council, Privy Council*); C. G. Aldridge (*Chairman, The Association of Supervising Electrical Engineers*); J. R. Beard, C.B.E., M.SC. (*Past-President; Honorary Member*); Surgeon Lt.-Cmdr. R. F. B. Bennett, V.R.D., M.P. (*Chairman, Parliamentary and Scientific Committee*); Rear-Admiral K. R. Buckley (*Director of Engineering and Electrical Training Division, Admiralty*); Dr. R. Cockburn, C.B., O.B.E. (*Chief Scientist, Ministry of Aviation*); T. E. Daniel, M.ENG. (*Chairman, The British Electrical Development Association*); A. G. Dawtry, M.B.E., T.D., LL.B. (*Town Clerk, The City of Westminster*); L. J. Dunnett, C.B., C.M.G. (*Permanent Secretary, Ministry of Transport*); H. Carleton Greene, O.B.E. (*Director-General, British Broadcasting Corporation*); T. G. N. Haldane, M.A. (*Past-President*); E. Le Q. Herbert, B.SC. (*President, The Royal Institute of Chemistry*); L. T. Hinton, B.SC.(ENG.) (*Chairman, The Electronic Engineering Association*); C. R. King, C.B.E. (*Chairman, The Electricity Council*); Col. B. H. Leeson, O.B.E., T.D. (*Past-President; Honorary Member 1960*); P. G. Masefield, M.A. (*President, The Royal Aeronautical Society*); D. D. Melvin (*President, The Institution of Gas Engineers*); Maj.-Gen. R. J. Moberly, C.B., O.B.E. (*Signal Officer-in-Chief, War Office*); J. C. Moston (*Chairman, The Cable Makers Association*); A. A. Part, C.B., M.B.E. (*Under-Secretary, Ministry of Education*); J. A. Ratcliffe, C.B.E., M.A., F.R.S. (*President, The Physical Society*); R. E. Robinson (*Chairman, Telecommunication Engineering and Manufacturing Association*); D. G. Shipp, B.SC.(ENG.) (*President, The Institution of Railway Signal Engineers*); R. Somerville, C.V.O. (*Clerk of the Council, Duchy of Lancaster*); Air Marshal H. D. Spreckley, C.B., O.B.E. (*Controller of Engineering and Equipment, Air Ministry*); Maj.-Gen. L. N. Tyler, C.B., O.B.E. (*Director of Mechanical Engineering, War Office*); D. Watson (*President, The Institution of Municipal Engineers*); Dr. H. F. Willis, C.B., M.SC. (*Chief of the Royal Naval Scientific Service*); L. A. Woodhead (*President, Scientific Instrument Manufacturers' Association*); and H. T. Young (*Past-President; Honorary Member*).

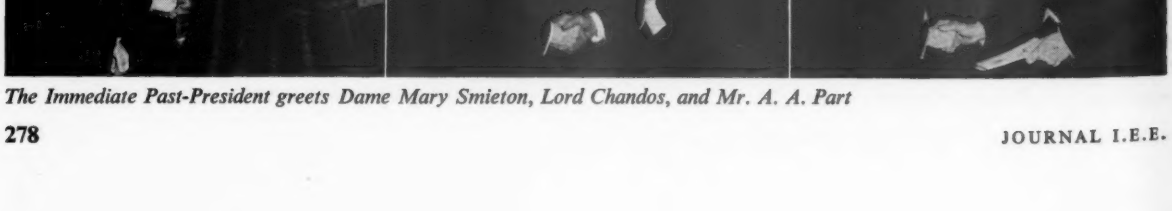
Grace before dinner was said by the Very Reverend E. S. Abbott.

Sir George Thomson

The Loyal Toasts, proposed by the President, having been honoured, Sir George Thomson, Master of Corpus Christi College, Cambridge, proposed the toast of 'The Institution of Electrical Engineers' in these terms:

'Your President, in asking me to propose this toast, was probably thinking of the part that physics has played in the birth of your branch of engineering. Physics was its mother, engineering was its father, and I suppose that Lord Kelvin was the leader of the important group of people who signed the bulletin. No other branch of engineering derives so closely and so completely from scientific investigation.

'Civil Engineering owes its seniority to the fact that it goes back to the days when someone cut down a tree to cross a



The Immediate Past-President greets Dame Mary Smieton, Lord Chandos, and Mr. A. A. Part

In these groups may be seen the Lord Chancellor, the Dean of Westminster, the Mayor of Westminster, Sir George Thomson, Mr. C. T. Melling, Col. B. H. Leeson, Lord Nelson and Mr. B. L. Metcalf

dangerous hazard. I suggest that on all formal occasions civil engineers should dress in skins and woad. They have not done so on this occasion, but I expect they do in private! Mechanical Engineering goes back only to the first water-wheel which, I am informed by my classical friends, dates only from the early Roman Empire. It would seem, therefore, that the toga is the appropriate full dress for the mechanical engineer.

'But you gentlemen are the product of a scientific age, of the nineteenth century, and for you this (if I may say so) rather uncomfortable costume which I am wearing is the appropriate one and the nearest to the kind of dress in which Faraday or Lord Kelvin might have appeared. From the days of Franklin's lightning conductor to the last nuclear reactor which the Central Electricity Generating Board is trying to foist on reluctant artists, you have used always the latest and the most efficient of the conclusions of science.

'I speak most sincerely when I say that the world owes a great deal to you. Without you, our age would be impossible. Our age is made by electrical engineering: electrical power is its blood and electrical signals its nervous system; microphones are its ears, television its eyes, and motors its muscles. Well, what do we get for being a father? Nowadays, it is usually the right of signing cheques; but youth, I have found, is extraordinarily generous, and you in your youth have abundantly repaid us for supplying you with some basic experimental facts.

'You have given us in return a wealth of special devices without which the science of physics today would be quite impossible. They range from those magnificent machines designed to produce atomic particles at incredible energies down to less spectacular but equally important things like the humble resistors and capacitors which, owing to the fact that you use them in countless numbers in your devices, we can buy for a few pence.'

Sir George referred to the use by students of physics of electrical devices and also to the discovery of the Van Allan radiation belt. He went on:

'I am sure that this connection between electrical engineering and physics will continue, to our mutual advantage. I must refer to one example with which I have had particularly close contact: the work which is being done at Harwell and Aldermaston on what are known as thermonuclear reactions, which is a long-winded way of saying an attempt to make energy safe for mankind for all time. There we see at its best the interconnection between the engineer and the physicist, but this is only one instance of many.

'A discovery in pure physics is taken up in electrical engineering and applied to many things, from invisible hearing aids to telecommunication. The discoveries of Lord Adrian and others on the way in which our brains work were due, as Lord Adrian himself has said, to electronic devices designed for a wholly different purpose.

'Recently, I am told, your contacts with medicine have become even closer than before. In July there is to be a conference on medical electronics and an exhibition of instruments. There is indeed an extraordinary, and perhaps to the layman rather terrifying, variety of medical applications, literally hundreds of them. I hope that I shall not myself experience more than a few! Isotopes are now quite old-fashioned, having been in use for at least 12 years.

'The transistor plays a part in the "radio pill", which, I am told, is a transmitting device designed to be swallowed. From the frequency of its radiation it is possible to measure quite a number of quantities, such as temperature and pressure, and it is used to study the digestion and the unborn child. Ultrasound is being used as an alternative to X-rays to avoid damage to sensitive tissues. The body will be investigated by a sort of ultrasonic radar and displayed on a screen.

'Finally, the electronic computer has a part to play in hospital organization. It is said (though I do not put much trust in it) that computers can be fed with information and the results of tests—including (and this is most important) what you say on being awakened at 6 o'clock in the morning, when you have just dozed off after a sleepless night—and will diagnose your case and say what is going to happen to you.

'I am not sure that this should be mentioned, because it seems to raise very difficult questions. Can you sue a machine for negligence if its diagnosis is wrong? Personally, I prefer a human being, who at least can be asked to explain. It seems to me that the machine resembles in one respect the limited-liability company, which, someone has said, has neither a soul to be saved nor a bottom to be kicked.

'I give you the toast of The Institution of Electrical Engineers, coupled with the name of your President, Sir Willis Jackson.'

Response by Sir Willis Jackson

The President, in the course of his reply, said:

'Thank you very much, Sir George, for your kind remarks about our Institution. I should like, if I may, to mention the outstanding positions and, from our point of view, the very

Sir George Thomson toasts The Institution

special positions which you and your famous father, Sir J. J. Thomson, have occupied in relation to the progress of electrical science and engineering.

'It by no means invariably happens that the son of a physicist chooses to be a physicist. It is unusual, if the father has been an outstanding physicist, for the son to justify the same description. Even if he did, one would not expect both of them to be elected to the Fellowship of the Royal Society, to be Nobel Prize-men and to be knighted. It is surely abnormal that, as scientists, both should become masters of colleges —which, of course, happens only in Cambridge anyway! It is unique for both father and son to be Faraday Medallists of our Institution.

'This is surely one of those occasions when the son must wish that the father could be present to observe the progress that the son has made; and one when we, who owe so much to the scientific achievements of Sir J. J. Thomson, should voice our gratitude to his son for the debt we owe to his father for his pioneering work in our subject.

'Let me now say how much I have looked forward to this opportunity to express more widely than is possible even in our large new Lecture Theatre my gratitude to the members of The Institution for electing me to the presidency.

'Sir George has been good enough to refer to the technological achievements of the members of our profession and to the contributions which we have made to the progress of science, and of physics in particular. I should like to supplement this by mentioning what many of you must know already, that the contribution which the electrical industry made to our export figure last year was £231·6 million, which reveals what a major contribution our 24000 Corporate members make to the health of our national economy.

'I want now to refer to some other aspects of our professional work and to the responsibilities which flow inevitably from them. In the first place, I would mention the increasing extent to which chartered engineers are coming to occupy the highest managerial and administrative positions within industry and commerce and in the public services, Government and other, and the demand which this makes upon them for more than mere scientific and technical competence; and secondly the increasing speed and directness of the impact of the achievements of chartered engineers on the life of the community both at home and oversea and the problems which they raise in the social sphere, of which the chartered engineer must take account in reaching his technical and administrative decisions.

'Thirdly, if I may quote from my Presidential Address, I would mention the emergence of the chartered engineer not only as a guardian and guarantor of our national economy, in a situation of increasing international competition, but also as a primary agent in a new international diplomacy in which much more than an expanding export trade is at stake; a situation in which, as participants in the industrialization of the underdeveloped countries, chartered engineers must carry conviction not merely as experts in their own scientific and technical specialities but also as ambassadors of unshakeable integrity, sound judgment and broad vision.

'To the requirement of scientific and technical competence there are being added, in increasing measure and with increasing speed, advisory and executive functions in the widening spheres of national and international affairs.

'We chartered engineers can no longer be content to be merely the creators and controllers of new forms of engineering equipment in all their technical complexity; the very impact of this creative effort involves us directly in the human and social problems which our work inevitably creates. Does the general public see the chartered engineer in the light of these achievements and responsibilities? There are times when I find myself doubting it, but I believe that we are entitled to attach importance to this only so far as it affects adversely the scale and more particularly the quality of the recruitment to our profession; if it impedes or affects adversely our participation in the solution of the national and international problems to which I have referred; or if it inhibits or restricts the advice and opinions which as chartered engineers we would wish to offer.

'If there are times when we have anxieties on these scores, I suggest that we should consider whether or not the reason, and therefore the solution, does not lie largely if not wholly within ourselves and whether or not the cause does not lie in substantial measure in the difficulty which the general public find in understanding the diversity of the men who are described as engineers and who in many cases carry the title of "professional engineer". In this connection I believe that we as an Institution, in co-operation with The Institutions of Civil and Mechanical Engineers, have taken a very important step forward in recent years by our collaborative efforts and by getting closer together in the discussion of common problems.

'This collaboration has taken the form of a number of joint committees, headed by the Three Presidents' Committee. It has also taken the form of the establishment by these three Institutions, jointly with The Institution of Chemical Engineers and The Institute of Physics, of the British Nuclear Energy Conference and the subsequent participation in this Conference of a number of other sponsoring bodies, and also the establishment, by some 40 institutions, institutes and societies, of the British Conference on Automation and Computation.

'There can, in my opinion, be no doubt that these exercises in collaboration have restrained, and I believe desirably restrained, the creation of still further specialist organizations. I regard it as of the greatest importance that this kind of co-operation should grow in extent and be strengthened as much as possible.

'Much as I hope and believe that this will happen, I think

that by itself it is likely to be inadequate. I therefore hazard the view that we shall bring great benefit to the engineering profession as a whole and contribute greatly to an appreciation of it in the public mind, more in keeping with the importance of its national service and potentialities, if we can devise a means of bringing the members of the primary constituent branches of our profession together under the common title which I have used several times this evening, that of chartered engineer.

'I must at once make it clear that by this I do not mean amalgamation, and for the simple reason that I think it essential not to restrain, and not even to appear to restrain, the vitality and initiative of the constituent branches. Nor do I wish to see the creation above these branches of a superstructure of administrative machinery. What I hope for is the minimal device which will ensure that chartered civil, chartered mechanical, chartered electrical and chartered chemical engineers in the first instance shall be seen publicly to be members of an integrated corporate body of chartered engineers.

'I do not suggest that the means of doing this will be easy to find, even if we all wish to achieve it—and there may be many who will disagree with the objective. I would express the hope, however, that those who disagree will not take it amiss that I have used this rather special and, for me, unique occasion to give expression to a view which I know also to be in the minds of several other senior members of our profession. I also express the hope that we may soon add clarity to this concept, if it is believed to be a wise one, through co-operative discussion among our institutions.

'In conclusion, let me return to the kind remarks which you, Sir George, have made about our Institution and its members. In the light of our past achievements and in the shadow of the problems which lie ahead of us, I thank you very sincerely for your good wishes.'

Mr. Goodall welcomes the guests

Mr. S. E. Goodall, Immediate Past-President, proposing the toast of the guests, mentioned the 'damped oscillation' suffered at the top table by Vice-Presidents and Past-Presidents. He went on:

'In recent years, however, I have observed, as no doubt you have, that there has been a tendency for a negative-phase-sequence component to creep in, as some of our Past-Presidents have hit on the bright idea of appearing here wearing other hats and so getting in as non-paying guests. One of the most notable who has pulled that off this evening is none other than our good friend Bruce Leeson. He has a first-class excuse, because it is our own fault that he is here as a guest: he is our 1960 Honorary Member and we are delighted to have him with us.

'You, Mr. President, have spoken of our principal guest, Sir George Thomson, and I do not propose to embarrass him still further, though it would be possible to enter on a very considerable discourse in extolling his many qualities and virtues. Suffice it to say how glad we are to have him with us and how very kind it was of him to address us as he did.

'We are particularly fortunate to be in the unusual position of having with us two very distinguished people who on previous occasions have addressed us. I am sure that they have had a much more pleasant evening now than they did on

The President replies

those occasions! Last year we had the very great privilege of listening to a brilliant address from the Lord Chancellor, Viscount Kilmuir, and we are delighted to have him with us again tonight. A year or two before we had the pleasure of listening to another brilliant orator, Dr. Charles Hill. We have to be very careful what we say in his presence, because I must remind you that he represents our landlord.

'We have a strong contingent of "top brass" from the Civil Service. I am sure that you would like me to make particular reference to one of them, the Permanent Secretary of the Ministry of Education, Dame Mary Smieton. It is comparatively rare, though it occurred last year, for us to have as one of our distinguished guests a charming lady, and we are particularly delighted that Dame Mary has so honoured us this evening. We have many contacts with her Ministry, particularly in the field of technological education.

'Representing the Church we have the new Dean of Westminster, Dr. Abbott. There are also present many distinguished representatives of the Services. During the last few days we have been reading a good deal about the money which they propose to spend on our behalf, and their budget reminds those of us who are married of the budget of our wives, who seem, like the Services, to spend vast sums of money and never have anything to wear. The representatives of the learned societies are, of course, our professional colleagues. They look so intelligent on an occasion such as this that I cannot understand why they sometimes fail completely to agree with our point of view on matters of professional interest.

'We are honoured by the presence of many of the leaders of our industry. This is the moment when I should dearly like to launch on a discourse on mergers, take-over bids and what have you, but I must remember that this is a strictly professional and not an industrial occasion. Some of my colleagues may think that I have a slightly ulterior motive also, in that I am sitting next to Lord Chandos.

'The representatives of the technical and daily Press, to whom we owe so much, have honoured us by their presence once again. I should also like to mention particularly the Honorary Secretaries of our Centres and Sub-Centres. They do a great deal of fine work for us with all too little recognition.

'At this point it was to have been my pleasant task to welcome as our final speaker the High Commissioner for

Canada. We very much regret that, owing to adverse weather conditions over there, he is unable to be here. It is therefore with particular gratitude that we welcome Councillor Group-Capt. Pirie, the Right Worshipful the Mayor of the City of Westminster, who has kindly promised to step into the breach, literally in the last hour.

'This is, I may remind you, not the first time that the R.A.F. have come to our rescue. I had in any case intended to mention his name, but, as he is now going to reply, perhaps I had better not mention the point I had intended to make. As we have our headquarters in Westminster I had intended to hint, ever so delicately, that he might deal very kindly with us in connection with those premises. Obviously it would be unfair for me to make that remark now, and so I shall not do so. We thank him for his presence and for being kind enough to step into the breach.'

The Mayor's reply

Replying, Councillor Group-Capt. G. H. Pirie said:

'When learning to fly I was required to study your science to some extent, and at that time I was able off my own bat to give an approximate definition of a joule, a coulomb, an ampere, an ohm and even a watt; but now, alas!, my memory has gone and I no longer have any knowledge of your science. But whereas in those days aeroplanes were relatively simple forms of conveyance, today they are, I suggest, a veritable paradise for the electrical engineer; but, unfortunately, despite the brilliance of your most learned Institution, even you have not earned the undying gratitude of all those who fly in aeroplanes by defeating the constant attentions of one of our distinguished forebears, Sir Isaac Newton.

'You referred, Mr. Goodall, to a small difference of opinion between your learned Institution and the Westminster City Council. It would be most impolitic for me to make any comment on a matter which is, I understand, *sub judice*, particularly in the most distinguished presence of the Lord Chancellor; but I should like to assure all my fellow-guests that the correspondence which is taking place between The Institution of Electrical Engineers and our Town Clerk has been couched in nothing but the most polite and generous terms, as one would expect from your learned Institution and as I hope you would expect from the ancient City of Westminster.

'Such innate good manners, however, are by no means universal in the relations between the great British public and what is commonly termed the local authority. As you all know—many of you, I hope, not to your undue cost—we have for some months past been operating parking meters. As you probably know, if you leave your car in a metered place for more than two hours an indicator comes up which says "extra charge", and if the attendant sees it while the car is there a slip is affixed to the windscreen telling you to send ten shillings to the City Treasurer, or else . . .!

'I do not think I shall bore you if I read three brief extracts from letters which we have received. The first is a little longer than the others, and reads:

"Please find 10s. enclosed. I should like to say here that I protest against the fantastic incompetence of whomsoever is responsible for installing parking meters with slots too small to receive pennies. Knowing the complete lack of understanding and tolerance with which I should be met if I tried to explain to you the injustice of this fine, I send you the money in order to avoid further correspondence with people of such small intelligence."

'The next two are quickies. I hasten to assure you, as do the patent-medicine advertisements, that these letters are genuine and can be examined at the offices of the Council:

"Many years ago it used to be a man with a black mask and a pair of pistols. Now it is parking meters."

'The last is particularly appropriate in a company which is almost entirely male:

"As ten bob is not worth fighting over, please find enclosed cheque for this amount, and may your mother-in-law live for ever."

'It is my happy duty to reply to the toast of the guests, so charmingly and ably proposed by Mr. Goodall. On behalf of all your guests this evening, I should like to say that for a magnificent dinner, for your generous hospitality and for your wonderful company we are deeply grateful.'

Completion of B.B.C. v.h.f. sound broadcasting station in Orkney

THE B.B.C.'s v.h.f. sound broadcasting station at Netherbutton, near Kirkwall, Orkney, was brought into full-power service on the 2nd May 1960. Since December 1958 temporary low-power v.h.f. transmissions of the Scottish Home Service only had been radiated from this station; this has now been raised to full power and the Light and Third programmes with Network Three are also transmitted.

The Scottish Home Service is radiated at 93·7 Mc/s as previously, the Light programme at 89·3 Mc/s and the Third programme together with Network Three at 91·5 Mc/s. A directional aerial is used giving a maximum effective radiated power of 25 kW. The transmissions are horizontally polarized, which means that receiving aerials should be mounted horizontally.

Orkney receives the three v.h.f. sound programmes direct from the B.B.C. v.h.f. station at Thrumster, near Wick, which in turn receives them from the v.h.f. station at Meldrum, Aberdeenshire.

The new station is expected to serve almost the whole of the Orkney Islands and the northern part of Caithness, where its coverage links up with that of the Thrumster v.h.f. station, which was brought into full-power service on the 1st March 1960. The combined population coverage of the two stations is approximately 43000.

V.H.F. transmissions are much less susceptible to interference from foreign stations and from electrical apparatus than are the long- and medium-wave transmissions, and they are also capable of giving much better sound quality.

The development of v.h.f. broadcasting has given a new opportunity for regional programmes, since each transmitter covers a smaller area. The v.h.f. transmitters on Home Service wavelengths are being used to give programmes of news and general local interest covering a smaller area than the regional news bulletins on the medium wavelengths.

621.335.3

THE ELECTROGYRO LOCOMOTIVE

Toy cars propelled by energy stored in flywheels are well known. A rather more sophisticated form of this principle has led to the development of electric locomotives which require neither batteries nor overhead wires or conductor rails. The National Coal Board are interested in the possibilities of this system for underground transport.

This article, which describes the construction and operation of an experimental locomotive, is based on a lecture delivered to a joint meeting of the Southern Centre of The Institution and the Southern Branch of The Institution of Mechanical Engineers on the 19th November 1959. Mr. Gessler is with the Central Engineering Establishment of the National Coal Board.

J. K. GESSLER, B.SC., ASSOCIATE MEMBER

OVER 1000 underground locomotives are employed in British coal mines, ranging from 190h.p. pantograph units operating in multiple down to 15h.p. locomotives for subsidiary duties. The majority, however, are 50–100h.p. Diesel or battery locomotives, and many duty cycles consist of a 10–20min run followed by a few minutes' shunting and waiting.

This method of working corresponds very closely to the operating cycle of an 'electrogyro', a combination of flywheel and induction motor built as one unit. The flywheel is brought up to speed by connecting this motor for a time to a 3-phase supply. When the locomotive leaves the charging point, the electrical machine is excited by capacitors and operates as an induction generator, converting kinetic energy stored in the flywheel back into electrical form to supply squirrel-cage traction motors. In service, a charge lasting 2–3min enables the locomotive to work for 10–20min.

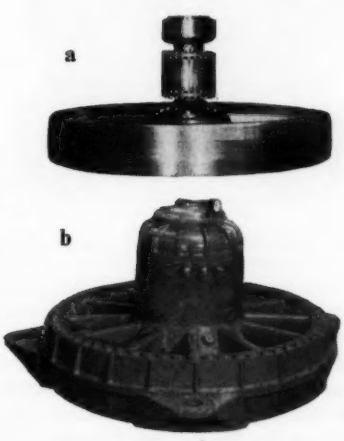
Such a system has obvious possibilities in the mining industry. But underground transport with its special difficulties and dangers is governed by a close network of rules and regulations. Trials are rather more conveniently conducted above ground, and the National Coal Board decided to have the experimental unit built as a surface locomotive. By making it a standard-gauge shunting locomotive of about 30 tons, they ensured that it would not only test electrogyros and control equipment in regular service and so provide data for possible underground units; it would, at the same time, earn its living in a colliery yard.

Construction

From outside, the only unusual features of the locomotive (Fig. 1) are two vertical masts which carry the charging contacts. At a charging station one mast swings out and presses these contacts against four bare copper bars which are mounted in insulating channels. The upper three are the power contacts; the fourth is part of a 24volt d.c. pilot circuit which ensures that the stationary contacts are dead unless a locomotive is actually charging.

1 *The electrogyro locomotive at a charging station*

Fig. 2a shows the rotating parts of the electrogyro with the upper bearing housing, and Fig. 2b the assembled unit. The 5ft 4in.-diameter flywheel is forged from nickel–chrome–molybdenum steel and weighs 1½tons.



2 *The electrogyro*

a flywheel with rotor of induction motor and upper bearing housing

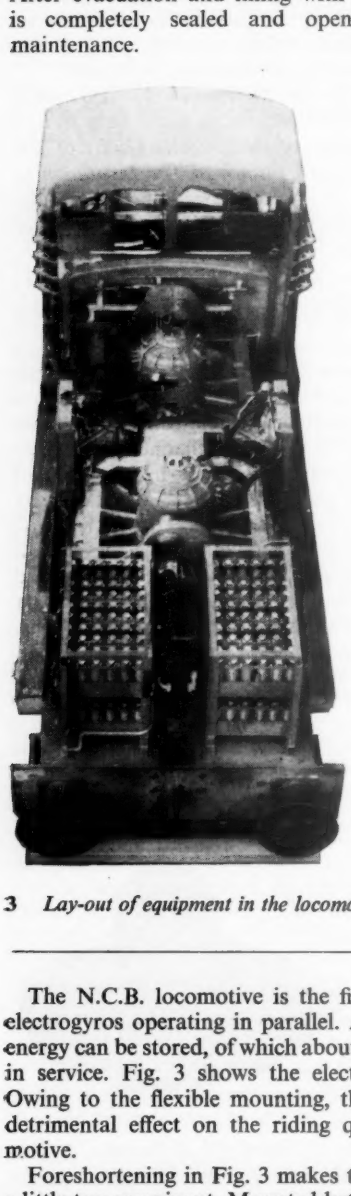
b assembled unit, showing electrical terminals, connections for water-cooling and alternative mounting of hydrogen pressure gauge

The whole rotating mass is suspended from one angular-contact ball-bearing; there is a guide bearing at each shaft end.

Tubular conductors are used for the squirrel-cage rotor winding, through which hydrogen at 10lb/in.² (absolute) passes at speeds up to 300ft/sec to transfer

heat generated in the windings to a water jacket around the stator. During charges the relatively small rotor must convert considerable amounts of energy into heat, and it is precisely the short-term overload capacity of this design which enables charging times in service to be kept so short.

There are no external shaft ends with their associated sealing problems; the only connections are electrical. After evacuation and filling with hydrogen, the casing is completely sealed and opened only for major maintenance.



3 *Lay-out of equipment in the locomotive*

The N.C.B. locomotive is the first unit to have two electrogyros operating in parallel. A total of 18 kWh of energy can be stored, of which about 12 kWh are available in service. Fig. 3 shows the electrogyros in position. Owing to the flexible mounting, the flywheels have no detrimental effect on the riding qualities of the locomotive.

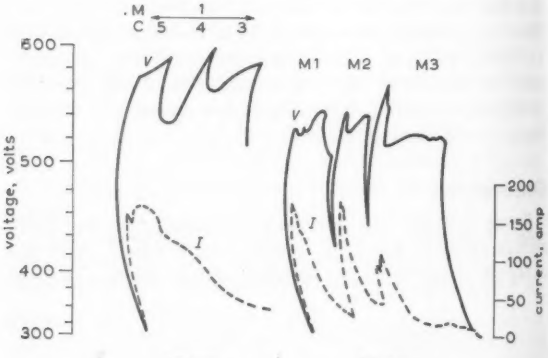
Foreshortening in Fig. 3 makes the capacitors appear a little too prominent. Mounted between the two capacitor banks is the air compressor which supplies air for braking and control. Normally it runs only when the locomotive is at a charging point, but in an emergency the compressor motor can be supplied from the electrogyros.

At either side of the bonnet, between the gyros, are radiators with their fan motors which also drive the cooling-water pumps for gyros and traction motors. The stators of the traction motors (which are similar to those used on small gyro mining locomotives) are water-cooled; internal cooling air for the rotors is supplied by two small motor-driven blowers. The traction motors are longitudinally suspended and drive the axles through double-reduction gears (bevel followed by spur).

Principle of excitation

It is well known that externally driven induction motors can be excited by means of capacitors. Motors with power-factor-correction capacitors may self-excite when the electricity supply is interrupted and, in the absence of precautions, dangerous overvoltages have on occasions been generated. This rather inconvenient phenomenon has been put to work.

When the flywheel rotates, the remanent magnetism induces a small alternating voltage in the windings. If sufficient capacitance is in circuit, this voltage causes a small leading current to flow. This magnetizing current strengthens the flux, increasing the voltage, which in turn further increases the magnetizing current. Voltage builds up in a manner analogous to that of a d.c. shunt machine.



4 *Current and voltage during acceleration (traced from recordings)*
- a starting a train in first notch on a gradient
- b accelerating the locomotive through three notches

An inherent characteristic of induction generators on load is that the output current leads the voltage. As the connected load, the traction motors, can absorb only a lagging current, the capacitor current 'completes the vector diagram'. The amount of capacitance required for excitation naturally depends on the frequency, and as the

flywheel speed is gradually reduced in service more capacitance is required.

The capacitors are connected in groups and controlled by the driver. An automatic control limits the generated voltage to safe values by reducing, if necessary, the number of capacitors in circuit to that required by the prevailing combination of flywheel speed, trailing load, gradient and locomotive speed.

Driving technique

Apart from air- and hand-brakes, the driver has only two controls: the pole-change lever and the capacitor-controller handwheel.

The squirrel-cage traction motors provide four running notches by successive reconnection of the stator windings. The arrangement reduces the time during which motors run with high slip when accelerating, and on some services can be used to counteract the effect of reduced flywheel speed:

notch	no. of poles	approx. locomotive speed	
		electrogyro	
		fully 'charged'	'discharged'
		m.p.h.	m.p.h.
1	12	4	2
2	8	6	3
3	6	8	4
4	4	12	6

The pole-changing feature is, in effect, a built-in gearbox; the capacitor control may be compared with the accelerator of a motor car; and transition inductors, which are automatically inserted for a short time during notching, act rather like a clutch. Notching up requires an increase in capacitance, and the driver moves the handwheel clockwise. As the train accelerates and the voltage rises to the permitted limit, excess capacitance is automatically switched out and the controller (and handwheel) rotates anticlockwise. If the gradient becomes more severe, the driver again moves the capacitor handwheel to increase excitation; a gentler gradient causes a rise in voltage which is again limited by the automatic control.

This operation at varying voltage is illustrated in Fig. 4, which shows voltage and current when starting a train in first notch on a gradient (Fig. 4a), and accelerating the locomotive through three notches (Fig. 4b). M indicates the motor notch and C the capacitor-controller position.

Pole-change traction motors have the useful feature of permitting regenerative braking without additional control gear. This very smooth and useful service brake has a regenerative efficiency of about 30%.

Charging

In order to limit heating of electrogyros, the flywheels are started from standstill at a reduced voltage, reaching maximum speed in 40–50 min. The N.C.B. locomotive usually charges at 220 volts for about 25 min in the shed, then runs a short distance to the 550 volt charging mast and completes the charge in a further 3 min. In service a normal charge requires a 3 min stop.

The parallel-connected capacitors are also used for power-factor correction during charging, when the electrogyros operate as simple squirrel-cage induction motors. Inductors connected in series with the gyro motors not merely limit the initial charging current, but also delay the reduction in torque as the electrogyros are nearing synchronous speed.

Operating cycles

Stored energy is proportional to the square of the flywheel speed, which places a lower limit on the useful flywheel speed in service. The N.C.B. locomotive normally works between 2900 and 1800 r.p.m., occasionally between 2950 and about 1500 r.p.m. In these ranges the energy abstracted from the flywheels is 10·3 and 12·3 kWh respectively.

Internal gyro losses have an important influence on duty cycles. The hydrogen filling at reduced pressure greatly reduces the windage (i.e. air or gas friction) loss and an electrogyro takes 11–12 h to come to rest from 3000 r.p.m. against 4½ h in air at atmospheric pressure. Yet windage and bearing-friction losses are far from negligible at high flywheel speeds, and extended discharge times naturally increase the proportion of internal losses. For maximum efficiency an electrogyro must therefore be worked as hard as possible.

Efficiency

For a rapid discharge (2950 to 1800 r.p.m. in 6 min) the conversion efficiency (flywheel to locomotive wheel) is 64% and the efficiency from charging mast to locomotive wheel is about 44%. 'All-day efficiency', which includes energy losses when the locomotive is standing and somewhat lower conversion efficiencies on runs longer than 6 min, is expected to be about 40% for underground duty cycles, i.e. of the same order as for battery locomotives.

Operating experience

At the test site, the 550 volt charging stations are situated at neighbouring collieries, 0·8 mile apart. Each charging transformer with its associated switchgear could, if necessary, supply several charging masts on different tracks. Until one of the collieries was closed, the duties consisted of shunting in either yard and transfer work between these collieries. The times between successive charges normally varied from 6 to 15 min, but occasionally exceeded 30 min when shunting.

The need to be in the vicinity of a charging station when the flywheel speed falls to 1800 r.p.m. involves no difficulty in shuttle service with known maximum loads if charging stations are correctly situated. During miscellaneous shunting an occasional look at the gyro speedometer, which quickly becomes a habit, warns the driver when a charge is required.

If a run has to be interrupted for some unusual traffic reason, the locomotive remains mobile for a substantial

time. The maximum possible waiting time naturally depends on the flywheel speed, but generally speaking is at least one hour, sometimes 2–3 h. In such an emergency the locomotive would leave its train when the line was clear, run light to a charging point and then return to pick up the train.

Future prospects

Gyro units, in common with all energy-storage vehicles, prefer fairly level routes. On a 1% gradient, for instance, two-thirds of the energy is used to overcome grade resistance. The amount of stored energy is at present relatively small, but can probably be substantially increased.

The capital cost of electrogyro vehicles is higher than that of orthodox vehicles. This factor, together with the limitations mentioned, restricts the applications in ordinary traction. There are, however, fields in which the higher capital cost may be balanced, e.g. by savings in the first cost of batteries and their replacement. (A battery mining locomotive may need three batteries for two working shifts, replaced every four to five years.) There appear to be prospects in specialized applications such as mining. In this connection it is of interest to note that a Russian flywheel locomotive with mechanical transmission has been tested and a production model for coal mines is being designed.

Summary

An energy-storage unit consisting of a flywheel with built-on induction motor is discussed, together with details of construction and operation of an experimental locomotive. The squirrel-cage motor which 'runs up' the flywheel also operates as an induction generator to transmit stored kinetic energy in electrical form to squirrel-cage traction motors. Capacitors needed for the self-excitation of the induction generator are used for power-factor correction during charging.

The system, which has so far been applied only to gyro buses and small locomotives, can in certain cases replace battery-electric vehicles or units supplied by overhead conductors.

This article uses some of the material contained in a paper of the same title presented by T. E. Green and J. K. Gessler to the Institution of Locomotive Engineers.* Any opinions expressed are the author's and not necessarily those of the National Coal Board.

* *Journal of the Institution of Locomotive Engineers*, 1959–60, **49**, Part 4, No. 270 p. 396

Industrial exploitation of research instruments

Many instruments designed for research on specific projects have much wider industrial application, although sometimes these research tools become little known outside the laboratory and valuable ideas remain unexploited. Several instruments developed in D.S.I.R. laboratories have already been taken up by industry and are marketed commercially. Others are covered by patents and are available for exploitation through the D.S.I.R.

Self-checking counter

The National Engineering Laboratory, for example, has designed an electronic counter in which all parts of the circuit are checked before each count. When the counting sequence begins, the functioning of the four transistorized decade units is first checked by counting a 1000 c/s checking signal for 1 sec to ensure that the resultant count is 1000; the decimal relay circuits are then checked for accuracy, the counter is re-set and its zero reading is noted. The operation takes 2 sec and an error signal halts the process.

Transistorized telemetering system

When signals are transmitted from moving parts of a machine to a stationary measuring instrument, the use of wipers, flexible leads or intermittent contacts gives rise to random noise and to mechanical fatigue of the contacts. The British Internal Combustion Engine Research Association has therefore developed a transistorized radio telemetering system particularly suitable for use with Diesel engines.

A transmitter complete with aerial is mounted inside a piston reciprocating in a cylinder transmitting temperature indications. The piston, with a transducer mounted in its crown, comes in contact with a heating element at the top of the cylinder and a compressed-air jet at the bottom. The varying output can be displayed on an oscillograph. This can be used for telemetering pressures, strains, etc.

Strip-speed meter

The reduction in thickness during the temper rolling of strip metal can be measured by comparing the speeds of the strip before and after rolling. A system of measuring these speeds without direct contact has been devised by the British Iron and Steel Research Association. A photocell is mounted in an illuminated spot, and the small irregularities in the light reflected from the strip surface give rise to a certain pattern in the cell's output. A similar cell mounted a fixed distance away in another illuminated spot produces a similar pattern after an interval of time depending on the strip speed.

If the output of the first cell is delayed (on a tape recorder) and added to the second photocell signal, a maximum combined output occurs when the delay introduced is equal to the time for passage of a point on the strip surface between the two photocells. The strip speed can then be calculated.

Electromagnetic printing chronograph

A portable machine which provides a permanent printed record of the time of arrival of signals, developed at the Cambridge University Psychological Laboratory, can be used for recording animal and human behaviour and performance. An essential feature is its digital time-base which avoids the need for a continuous paper feed.

51ST KELVIN LECTURE MEETING

Presentation of Institution Honours and Prizes for 1960

STUDIES OF COSMIC RADIATION BY PROF. C. F. POWELL

THE Ordinary Meeting for the 51st Kelvin Lecture on the 31st March 1960 was held in the Lecture Theatre at Savoy Place, and was as usual very well supported. After the minutes of the Ordinary Meeting on the 3rd March had been taken as read, the President, Sir Willis Jackson, welcomed the new Corporate members in the customary short ceremony.

The names of the scrutineers of the ballot for the election of new members of Council were approved by the meeting.

New Honorary Members

The President then explained that each year the five immediate Past-Presidents and the reigning President nominate for election by the Council an Honorary Member and a Faraday Medallist, with the variation that not more frequently than once in every three successive years they may nominate an additional Honorary Member who is not a member of any grade of membership of The Institution. So it was that this year there were two Honorary Members.

Speaking first about Col. Bruce Hamer Leeson, C.B.E., T.D., President in 1952–53, who had been elected an Honorary Member in the 'ordinary' category, the President continued:

'. . . not that Col. Leeson is an ordinary man by any means, or he could not have performed with such success and distinction the difficult task which falls to the Director of the British Electrical and Allied Manufacturers' Association, a post which, prior to his recent retirement, he had held since 1945 and in which he gained the gratitude, respect and affection of the membership of our profession in a very wide sense of the word.'

He recalled that Col. Leeson had been employed from 1919 by A. Reyrolle and Co., Hebburn, of which he became managing director in 1940. He was concerned with the establishment of the first short-circuit switchgear testing station in this country in 1929 and subsequently with the standardization of switchgear performance which enabled certificates of rating to be issued.

During the 1914–18 War he had served in the Divisional Engineers of the Royal Naval Division, and he subsequently retained his attachment to the Territorial Army and was Commanding Officer of the Tyne Electrical Engineers at the outbreak of war in 1939. He had been immediately granted leave of absence by Reyrolle's to assist in the planning of the Tyneside anti-aircraft defences and in the establishment of a factory for the production of gyroscopic sights for the Royal Air Force. On his return to Reyrolle's he had been appointed Honorary Colonel of the Tyne Engineers. For these and other important services he was honoured by the award of the Territorial Decoration and was appointed a Commander of the Order of the British Empire.

The President continued:

'Of his great services to The Institution I need only say that he was Chairman of the North-Eastern Centre in 1930, a Centre which is characterized by its vigour and enthusiasm and by the very notable distinction that it has provided from among its Past-Chairmen five Presidents of The Institution. He became an Ordinary Member of Council in 1946 and our President in 1952.'

The President spoke of Col. Leeson's continued interest in the training of electrical engineers, his part in achieving the endowment by B.E.A.M.A. of the chair of electrical engineering at Cambridge University, and his chairmanship of Faraday House Engineering College.

'He has recently retired, though not, I assure you, to inactivity. I think it will give you pleasure, Col. Leeson, and will also give pleasure to Mrs. Leeson, whom I am delighted to see here this evening, to read again from time to time our citation, that you be elected to Honorary Membership in recognition of your extensive contribution to the application of electrical science and engineering in the manufacture of electrical plant and equipment, to the development of co-operative effort within the electrical industry, and of the services you have rendered to The Institution over more than half a century. In asking you to sign our Book of Honorary Members I would convey to you on behalf of all your colleagues within The Institution our immense gratitude for all that you have done for us.'

Col. B. H. Leeson

The President then, amid applause, presented the vellum certificate of Honorary Membership to Col. Leeson, who signed the Honorary Members Book.

In replying, Col. Leeson recalled his thrill in 1908 on being enrolled as a Student member of The Institution. He spoke of his feelings then of pride and good fortune in having been enrolled, and at the same time as an 'ordinary' man (of which

he had just been reminded) of the inheritance which he was going to receive from those in the industry who had been eminent and had created The Institution.

He went on:

'It seemed as though the door of opportunity had opened and that there lay before me a life offering something constructive and a life of adventure. To youth, adventure is not expecting to experience the expected; on the contrary, it is to experience the thrill and the excitement of the unexpected, the enchantment of surprise. Tonight the presentation to me of the certificate of Honorary Membership has had its full quota of adventure, inasmuch as it represents the full measure of surprise and therefore enchantment. I wish to thank you, Sir, and the Council and all the members of The Institution for the great honour that you have conferred upon me, to say how much I appreciate it and to ask you to accept my very grateful and humble thanks.'

He had sometimes wondered, particularly as a young man, what were the qualifications and characteristics which made those men great. Had they inborn genius, which without any effort came to the front and enabled them to do such wonderful things, or were they really developing their talents and working very hard and conscientiously for the good of The Institution? He recalled from his school-days some words of Longfellow:

> 'The heights by great men reached and kept
> Were not attained by sudden flight,
> For they, while their companions slept,
> Were toiling upwards in the night.'

He felt that this was a great inspiration to those who, as ordinary men, felt that if they had not the talents of the genius they could contribute something, as people who were just 'ordinary'.

He thanked the President for the personal way in which he had made the presentation, and expressed his gratitude to the President and the Council for inviting his wife to be present. Here he smiled and remarked:

'I was going to say my Home Secretary, but it would be better to say my Chancellor of the Exchequer, particularly as I have retired—because she is one to whom I always owe so much.'

Turning to The Institution itself, Col. Leeson spoke of the opportunity for a man to develop his talents by mixing with others who were doing the same, and to communicate the results of those talents in the form of contributions to The Institution, instead of asking 'What does The Institution give me?' The technical and other information fed in by members was then available collectively to the consumer—the public—or, in the words used in welcoming new members, 'to the community that we serve'.

The *esprit de corps* of The Institution had played a tremendous part in the national welfare of the country, and, although part of the industry was under private enterprise and part under public ownership, behind anything that had to do with organization there was the close co-operation of the professional engineers on all sides of the industry, who co-operated one with the other first and foremost from a professional point of view in giving to the public an adequate supply at an economic price with safety.

He had the other day wondered how, when history came to be written and the events of centuries were condensed into a very few words, a scribe in some distant age might describe the developments that he had seen over half a century in the electrical industry. He thought it might read:

'And in those days many wise and learned men did probe the secrets of nature and did make strange things, and they oft did journey unto the great city and did meet in a noble place in the precincts of the Temple, where they did give of their knowledge one to the other for the benefit of all. And in due season they did feast with their friends and the rulers of the land and did declare unto them saying "Nature hath delivered unto us electricity, and henceforth shall the labours of our people be multiplied and the lives of our people greatly exalted". And it came to pass that diverse tribes worked as one tribe and by their deeds out of the earth came forth light and power and out of the ether came voice and vision.'

Introducing the second Honorary Member for 1960, Dr. Richard Lancaster Hearn, the President told us that Dr. Hearn was born in Toronto and graduated from Toronto University in 1913 with the degree of B.A.Sc.

Immediately after graduating, he had joined the Hydro-Electric Power Commission of Ontario, the organization of

Dr. R. L. Hearn

which he was to become chairman in later years and with which he was destined to contribute so much to the development of large-scale power generation in Canada. After an initial appointment as design engineer on the Wasdale Falls and other projects, he had served as assistant engineer on construction from 1918 to 1921.

From then until 1942 he had held various appointments outside the Commission, both in the United States and in Canada, finally being appointed chief engineer of H. F. McLean Ltd. in 1934.

When he rejoined the Ontario Hydro Commission in 1942, as executive assistant to the chairman, he was seconded to the Polymer Corporation to supervise the construction of their synthetic-rubber plant at Sayner. In 1944 he transferred to act as Canadian technical adviser to the Public Utilities Division of the Combined Production and Resources Board at Washington, D.C., for a year. At the end of the war he returned to the Hydro Commission as chief engineer. He was appointed general manager in 1947 and chairman in 1955.

While he was chief engineer, two steam thermal plants were commissioned, one of which, then the largest in Canada, bore his name, the Richard L. Hearn Station in Toronto. During his time with the Commission the harnessing of the Niagara Falls for power generation was carried out and a similar project started on the St. Lawrence. A further major achievement with which he was associated was the change of frequency standardization from 25 to 60c/s at an over-all cost of $655 million.

The President continued:

'Dr. Hearn is a director of many organizations, but one appointment has offered particular scope for the fulfilment of his keen and constant desire to see the natural resources of his country harnessed for the lasting benefit of her people. This has been a directorship in Atomic Energy of Canada Ltd., which he accepted in 1952, the same year as that in which he received an honorary doctorate from his old university. His connection with the development of atomic energy in Canada has formed a major part of his professional interest in recent years and has led him to make contact with the nuclear field in this country by annual visits to Harwell, Risley and other projects.'

Dr. Hearn is a member of the Engineering Institute of Canada, of the American Society of Civil Engineers, and of the American Institute of Electrical Engineers. The Engineering Institute of Canada awarded him the Julian C. Smith Medal in 1954 and the Sir John Kennedy Medal in 1957. Having retired in 1956 from the chairmanship of the Ontario Hydro Commission he remained a very active engineer, and his guiding hand was welcomed in the organizations which retained his services in an advisory capacity.

The President invited Dr. Hearn to sign the Book of Honorary Members and to accept the certificate of Honorary Membership 'in recognition of our great appreciation of what you have done not only for electrical engineering in Canada but for collaboration within the British Commonwealth.'

Dr. Hearn then, amid applause, received the certificate of Honorary Membership from the President and signed the Honorary Members Book.

After signing, Dr. Hearn said:

'On an occasion such as this it is difficult for me to express my appreciation of the honour which has been done me. It has a particular significance for me in that a member of this Institution, who was chairman of a committee investigating the subject, in July 1890 made a public statement in Brown's Hotel in London to the effect that in his opinion and that of his committee the way to develop power from the Niagara River was by the electric method. That makes me feel that I am at home here; in other words, this is the mother Institution of electrical energy in Canada, where I have had the privilege of playing such a large part in the last 45 years.

'You will pardon me for saying that I do not remember that announcement, because at the time I was only two months old, but I checked it at Brown's Hotel a few years ago and you will find it there.

'As a youngster in Toronto, when the first power came to Toronto over the transmission lines I asked my father, who was a medical doctor, how electricity was obtained from Niagara Falls. The newspapers contained great headlines of this wonderful development of bringing power 90 miles from where it was generated by the falling water of Niagara Falls. The answer I got was "These three wires which you see on the telegraph poles" [as he called them] "run all the way back to Niagara. They dip into the water as it goes over the falls, and that is how we get electric energy." Think of all the fun we should have missed had it been as simple as that!'

He looked back on all that had transpired since that time and at the contribution to mankind made by the members of The Institution and of the profession in developing what he regarded as the one fundamental form of energy that kept the universe alive. Lord Kelvin, in whose honour the Lecture was being given that evening, was in fact the chairman of the 1890 committee referred to. Lord Kelvin had also contributed to some extent to the choice of a.c. generation at Niagara.

Dr. Hearn recalled that when they reached the stage in Ontario when falling water was not furnishing all the power they needed, they had turned to thermal power, and the generators for the first thermal station had been provided by Great Britain. Later, Ontario, lacking enough coal, had turned to nuclear power, and there again members of The Institution had played a large part in the development of atomic energy for peaceful purposes.

He concluded:

'It has been my good fortune to be associated with these developments throughout. I thank you from the bottom of my heart, for in receiving this honour I feel that I receive it not only on my own behalf but on behalf of those thousands of engineers and construction men and others who have been associated with me in all these projects which have made it possible for me to be here today and to receive this outstanding honour from your Institution.'

Faraday Medallist

The President then came to the award of the Faraday Medal for 1960 to Sir George Thomson, D.SC., F.R.S., who, in recognition of his pioneer work and his leadership in physics had received many university honours and the Fellowship and the Hughes and Royal Medals of the Royal Society, as well as a Nobel Prize in 1937 for his researches on electron diffraction. He was then Professor of Physics at the Imperial College of Science and Technology, University of London, having previously occupied the Chair of Physics at Aberdeen University and still earlier held a Fellowship at Corpus Christi College, Cambridge.

The President said:

'His study of that not-so-neutral particle, the neutron, in the late 1930's was of major importance in revealing the possibility of producing large-scale atomic explosions—not, I am sure, Sir George, the kind of outcome of your scientific work which gave you any satisfaction.'

He recalled that in 1940 Sir George became Chairman of the first British Committee on Atomic Energy, and in 1943 scientific adviser to the Air Ministry, followed in 1946 by a similar service to the British delegation at the United Nations Atomic Energy Commission. By that date he was contemplating experiments, which he later initiated at Imperial College, directed towards the possibility of controlled thermonuclear reactions, work which had since been pursued in parallel with the Zeta project at Harwell.

In 1952 he had returned to Cambridge as Master of Corpus Christi College, and, as a culmination of his manifold services to science, was now President of the British Association for the Advancement of Science as well as of the Institute of

Physics. His work for physics and for young people who had chosen to devote themselves to physics was of particular significance and of immense value to the progress of electrical engineering.

The President concluded the citation by referring to Sir George's family record, reminding members that he was the

Sir George Thomson

son of one of the famous fathers of their subject who became an Honorary Member of The Institution in 1907 and a Faraday Medallist in 1925, the late Sir J. J. Thomson, whose portrait would normally be hanging in the Lecture Theatre but was absent during the alterations and rebuilding. He said:

'We shall all be extremely pleased and honoured if, Sir George, you will join your distinguished father as the recipient of our Faraday Medal in recognition of your outstanding contribution to the advancement of electrical science, of the leadership in research which you have given to others in this field, and of your inspiring services to education and to technology.'

Amid warm applause, the President then presented the Faraday Medal for 1960, the 38th award, and certificate to Sir George Thomson.

Sir George replied:

'It would be impossible in the time allowed me to thank you adequately for this very great honour that your Council has done me, and so I shall not try to do so. I shall merely say that what must be an intense pleasure to anyone in my position is multiplied many times by the fact to which the President has referred, that I am succeeding my father in receiving this Medal.

'My father in his early youth intended to be an engineer and was prevented only by financial difficulties—his father died at an early age—and all his life he kept the engineering point of view. He always looked at a thing to see whether or not it would work. He was a great mathematician, but he never allowed his mathematics to run away with his physics or, as I would prefer to say, with his engineering. If I inherit anything from him, I hope it is this practical and visual point of view towards science. Thank you very much.'

Institution Prize-winners

Presenting the Page Prize to Mr. G. T. Gillies, who also received an Institution Prize, the President said that at the age level with which they were now dealing, this achievement compared in significance with the awards which he had just announced, and he hoped that members would salute Mr. Gillies with the same enthusiasm that they had shown to his more senior colleagues. The Page Prize is awarded annually to the best candidate obtaining distinction in all compulsory subjects in the final year of the Higher National Certificate course in electrical engineering.

Announcing the award of the Henry Nimmo Prize for the first time, the Secretary explained that it had been founded by the Council, on the basis of a benefaction, to commemorate the interest which Henry Nimmo, a past member of Council and Honorary Treasurer of The Institution, took in the education of all those who were entering the electrical engineering world, not only technologists but technicians and craftsmen too.

This year the first award was made to a student of outstanding merit who obtained an electrician's certificate of the City and Guilds of London Institute under the regulations applying to electrical technicians' courses. After very careful selection, it had been awarded to Mr. B. W. Friend, of Newbury.

Forty-six Institution Prizes had been awarded this year on the results of the Institution Examination, and presentations were made at the meeting to Prize-winners in the London area, including the Page Prize-winner under the new ruling that he was not to be excluded from obtaining an Institution Prize also.

THE KELVIN LECTURE

The President then called on Prof. C. F. Powell, M.A., PH.D., SC.D., F.R.S., Melville Wills Professor of Physics, University of Bristol, to deliver the 51st Kelvin Lecture, saying:

'It is not often that we have two Nobel Prize-winners in this Lecture Theatre, but Professor Powell is a very worthy partner of yours, Sir George, as I am sure that you will agree, for he

Prof. C. F. Powell

has done pioneer work of the highest distinction in the study of cosmic radiation, and more generally in nuclear physics.'

The origin of cosmic radiation

Prof. Powell introduced his subject by summarizing what is already known of the nature of cosmic radiation. It is composed of atomic nuclei of great energy which approach the Earth from out of space. Their directions of motion are isotropic; the particles appear to come equally from all directions. As a result of work in the past 12 years, it is now known that in addition to hydrogen nuclei—the protons—which form about 90% of the incoming particles, the radiation contains about 9% helium nuclei (α-particles), and 1% heavier nuclei. The tracks shown in Fig. 1 were made on sheets of film coated with photographic emulsion which were sent up with a balloon. The histogram showing the relative frequency of occurrence of nuclei of different chemical elements in the primary cosmic radiation is referred to as the 'charge spectrum' of the radiation.

The particles of the primary cosmic radiation are not all of the same speed; they are distributed in energy in an 'energy spectrum'. A considerable fraction of the primary protons have energies much greater than any we can generate in the great accelerators. Thus the great proton-synchroton at Geneva produces beams of protons each with an energy of $2{\cdot}5 \times 10^{10}$eV. A small fraction of the cosmic particles have energies more than 10^7 times greater than this. The cosmic particles therefore allow us to study the effects of the collisions between elementary particles in a range of energy very much greater than anything we can approach in the laboratory.

The existence of cosmic radiation poses questions of great interest for contemporary cosmology. Where do the particles originate in the universe, and by what processes are they given their great kinetic energy? Today a plausible account can be given of the origin of cosmic rays as a result of a detailed knowledge of the charge spectrum and energy spectrum of the radiation; and through recent developments in theories of stellar evolution, and a knowledge of the conditions in interstellar space based on studies of radio astronomy.

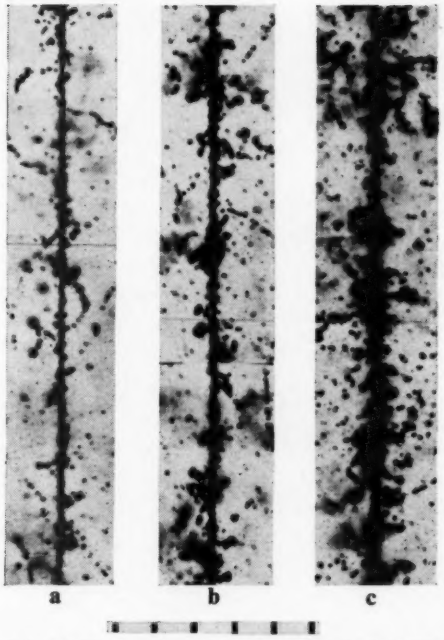
Two unusual features

Two features of the charge spectrum of cosmic radiation gave a clue to recent speculations. The relative abundances of different elements in cosmic radiation can be compared with similar results for the matter of the universe. The abundances of the elements in the universe can be estimated from the chemical composition of the surface layers of our own planet, from the constitution of meteorites, and from a study of stellar atmospheres.

While the results for cosmic radiation are similar to those for ordinary matter, there are two important points of difference. First, whereas the light elements, lithium, beryllium and boron, are very rare in ordinary matter they are common in cosmic radiation. Secondly, the heaviest elements in the cosmic radiation, nickel and iron, are about ten times more abundant in cosmic rays than in ordinary matter. Nickel and iron are over-abundant in cosmic radiation.

Evolution of a super-nova

A reasonable explanation can now be put forward of why lithium and beryllium are rare in ordinary matter. A star



1 *Tracks of three heavy nuclei of the primary cosmic radiation moving with velocities approaching that of light*

The different appearance of the tracks with changing nuclear charge is apparent. The spurs are due to electrons ejected from the atoms through which the primary particle passes; by counting the number of spurs in a given length of track, the charge of the primary particle can be estimated

a neon (charge 10)
b silicon (charge 14)
c calcium (charge 20)

starts its life as a great diffuse gas-ball, which becomes denser through the gravitational attraction between its parts. As it contracts, it tends to heat up through the release of gravitational potential energy. When the central temperatures reach about 10^6 °C, thermonuclear reactions between protons and any light elements in the star can occur and the latter are rapidly transformed. Further collapse then occurs until the central core of a star with a mass like that of our sun reaches about 15×10^6 °C. The main reactions involved in building up four hydrogen nuclei into helium nuclei can then take place, and these processes supply the energy generation during the main radiating life of the star—say 10^{10} years for a star like our sun.

Stars more massive than the sun can evolve much more quickly. In some of them a series of stages of energy generation occurs, with increasing central temperatures, and involving the production of nuclei of increasing complexity. In the case of a small proportion of massive stars, a stage is reached where a considerable proportion of the mass of the core of a star is transformed into nickel–iron. No further energy can be gained from matter in this state, and at a certain stage the core collapses. The mantle of gas surrounding the core, still rich in hydrogen and helium, then collapses into the central regions of high temperature. There, reactions which occur very slowly in the earlier stages in the life of a star can take place explosively. A violent catastrophe occurs,

2 *Inflation of polythene balloon before launching*

Only about 1% of the balloon's volume is inflated at ground level. The balloon is held down by a polythene canopy which takes the main stress and prevents excessive surging of hydrogen at the moment of release. When the balloon is released, the lines from the canopy, passing round drums, set two flywheels in motion; this restricts the upward acceleration during the first few seconds of the launch to less than about 1*g*

which appears as a super-nova, and much of the structure of the star is blown apart. The relic of such a super-nova explosion, that of A.D. 1054, can be seen today as the Crab nebula.

Cosmic rays are thought to be generated in the relics of super-novae. Recent studies of the Crab nebula show that electrons of very great energy are indeed being generated within it. It is a reasonable assumption that fast nuclei could be accelerated by processes similar to those acting on the electrons.

Such an origin allows us to account for the over-abundance of nickel–iron in cosmic rays, for we have seen that these elements are manufactured in a star in the stages of stellar evolution preceding the super-nova explosion.

Isotropic nature

But the cosmic rays do not appear to be reaching us from localized sources such as the Crab nebula; they are isotropic. This can be explained as a result of recent observations which show the presence of diffuse clouds of gas, and associated magnetic fields in the diffuse halo of gas with which our own spiral galaxy, like many others, is surrounded. Magnetic fields deflect moving charged particles, and we may assume that the primary particles injected into the galactic halo suffer random deflections in passing through the randomly oriented magnetic fields. Their directions of motion are thus rendered isotropic.

Further, it is believed that as they pass through the tenuous gas of the halo, the original particles may from time to time make collisions with the nuclei of the diffuse gas. In such collisions, the heavier nuclei will sometimes fragment, and among the products will be some nuclei of lithium and other light elements. It is thus, so it is thought, that the light elements are introduced into the stream of particles reaching the Earth. From estimated values of the density of gas in the halo, and the observed proportion of light elements in cosmic radiation, we can determine the average time which elapses between the instant of injection of the cosmic particles from a super-nova, and their arrival at the Earth. The result is of the order of tens of millions of years.

Prof. Powell rounded off his Lecture with a brief extract from a film showing the launching of a balloon, which, until a suitably designed satellite came on the market, was the best medium for carrying instruments to over 100000ft and maintaining them there for 24 hours. Fig. 2 shows a typical balloon being partly inflated on the ground.

A vote of thanks to Prof. Powell was proposed by Sir Noel Ashbridge, who congratulated the author on the delivery—extempore—of a very fine Lecture. He reminded us that the object of the Kelvin Lectures was not to provide material of immediate interest to the ordinary electrical engineer, but rather to keep the members of The Institution in touch with various advances in physics; and that there was no discussion after Kelvin Lectures.

Mr. G. Millington, seconding the vote of thanks, waxed reminiscent over his days in the Cavendish Laboratory, when he knew the Lecturer, if only 'distantly'. Prof. Powell had shown us that truth was stranger than fiction, even scientific fiction; but he thought that what he had said was 'very plausible'.

The vote of thanks was carried by acclamation, whereupon the President declared the meeting closed. The Lecture will be published in full in the *Proceedings* of The Institution.

ULTRASONIC LEVEL GAUGE

ULTRASONIC transducers are being used by the United Kingdom Atomic Energy Authority to define remotely the level of the interface between aqueous and solvent phases during a purification process in the recovery of uranium from spent fuel-elements.

The radioactive solution made by dissolving the elements in nitric acid (aqueous phase) is brought into contact with tributyl phosphate (solvent phase) by counter-current flow in mixer-settler tanks. Uranyl nitrate passes into solution in the solvent phase and the fission-product impurities into the aqueous phase, separation being ensured by repeated operation. Scum and sediment, however, obscure the interface between phases.

Signals are transmitted into the contents of the tanks and the reflected signals are picked up and displayed as modulations on a cathode-ray tube.

The transducers could also be used to obtain cross-sectional representations of the tanks.

Meetings of the Council on the 31st March and 28th April 1960

The following summary of reports received and decisions reached by the Council of The Institution at their meetings on the 31st March and 28th April 1960 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meetings, as some items must necessarily be regarded as *sub judice*.

31ST MARCH 1960

1959 Accounts

These were introduced by the Honorary Treasurer in their new expanded form and approved for inclusion with the Annual Report of the Council, which will be available at The Institution's Annual General Meeting on the 19th May 1960.

Joint British Committee for Stress Analysis

At the last meeting of the Council (see p. 218 of the April 1960 *Journal*) the Finance Committee had been asked to confirm that they would be in a position to vote an annual sum of £30, to cover the amount of The Institution's subscription to this Joint British Committee. Mr. C. T. Melling, Chairman of the Finance Committee, was now able to confirm that they had done so.

Engineers' Guild—survey of engineers' salaries

The Council considered a notification from the Engineers' Guild outlining a proposed survey of engineers' salaries, which they were proposing to carry out through an expert organization on a sampling basis and which would supplement the figures given in the Pilkington Report on the salaries of doctors and dentists. It was decided that the Guild should be informed that, in the view of the Council, it would not be improper for a member of The Institution to complete a questionary received from the Guild in this connection, even if he was not a member of the Guild.

Joint Committee on the Applications of Electricity in Aircraft

The Council approved a recommendation from this Joint Committee, supported by the General Purposes Committee, that a Discussion Group be set up jointly with the Royal Aeronautical Society to provide a forum wherein workers engaged in the fields of aircraft construction and electrical engineering could discuss problems of common interest.

Committee appointments

On the recommendation of the General Purposes Committee and the Education and Training Committee, several appointments and nominations to other committees were approved. Details will appear in the *Journal* in due course in 'Announcements to members'.

National Certificates and Diplomas in Electrical Engineering, 1958–59 Session

Prof. M. W. Humphrey Davies, on behalf of the Chairman of the Examinations Committee who had been prevented from attending the meeting, introduced the annual reports of the three Joint Committees for National Certificates and Diplomas for (a) England and Wales, (b) Scotland and (c) Northern Ireland respectively.

The Council noted with interest that the number of approved National Certificate courses had continued to increase and that there had also been a greater number of candidates, although this had been accompanied by a slight decrease in the percentage of successful students in certain colleges. It was satisfactory to note that the pass lists had for the first time been issued before the 1st September and it was acknowledged that this was largely due to the sustained efforts of The Institution's staff.

Henry Nimmo Prize

The Examinations Committee had also considered revising the conditions of award of the Henry Nimmo Prize. The principal change proposed was that the first selection of students should be made on the results of the final examination instead of the intermediate examinations; the opportunity had also been taken of putting the conditions of award into a more logical order. The Council agreed to the Committee's amendments.

Special Advisory Committee

Mr. O. W. Humphreys, Chairman of the Special Advisory Committee set up in 1959 to study ideas and suggestions received from members and to review the channels of communication between the Council and the general membership of The Institution (see November 1959 *Journal*, p. 649), introduced the advanced draft of Part 1 of the Committee's report. Although the formidable task of reviewing the broad range of subjects referred to the Committee had not been completed, it had been felt that the first part of the Committee's report should be submitted now, in the form of an advanced draft, in view of the Council's desire for information about the progress of the Committee's work.

The topics covered in this draft are mainly related to the organization of, and communication within, The Institution, and the Council decided to seek the advice of their expert standing committees on the recommendations which it contains. The President expressed the indebtedness of the Council to the Chairman and members of the Committee for the time and care they had devoted to this painstaking review.

Committee on Regulations for the Electrical Equipment of Aircraft

The Council approved, for transmission to the Air Registration Board, recommendations by the above Committee for the revision of Chapter 2, Section J (Electrical), of the British Civil Airworthiness Requirements.

Council Nominations

The President reported that those invited had accepted nomination for election to the Council for the 1960–61 Session (see April 1960 *Journal*, p. 252).

Society of Polish Electrical Engineers in Great Britain

The Council were gratified to learn that this Society had passed, at their recent Annual General Meeting, a motion voting their sincere thanks to The Institution for the interest and assistance shown to them during the past year.

28TH APRIL 1960

Membership

After approving 20 applications for election and 61 for transfer, as recommended by the Membership Committee, the Council gave final confirmation to the election and transfer of those candidates whose names had been published with the March 1960 *Journal*, to become effective from the 2nd May 1960. Taking these into account, the total membership at that date would be 46287.

Risks to members during visits

The Council approved a recommendation from the General Purposes Committee that the following wording should be adopted for use by The Institution for the purpose of disclaiming responsibility for injury etc. to members caused in consequence of visits arranged by The Institution, and printed on all forms to be returned by members applying to attend Institution visits:

'*Visits to works*

The Institution hereby gives notice that all arrangements made by The Institution for a member to visit an engineering or other works are made by The Institution as agent for such member, and that consequently The Institution accepts no responsibility or liability for any injury, loss or inconvenience caused to such member in consequence of his visit.'

Goldup Prize

Mullard Limited have offered to provide funds for an annual Prize in commemoration of the late Mr. T. E. Goldup. The Council have accepted this generous offer with grateful appreciation.

The Prize will be offered to the best of those candidates who obtain distinctions in each compulsory subject—including one paper in electronics, communication or an allied subject—of the final year of the Higher National Certificate in electrical engineering. The new Prize will thus complement the existing Page Prize, which will henceforth be awarded in respect of 'heavy current' subjects only. The details of the operation of the Prize were referred to the Examinations Committee.

Fees for National Diploma Examinations

The Council had already agreed to a proposal from the Scottish Education Department regarding an increase in the fees payable in respect of National Certificate Examinations in Scotland; the Department now proposed that the scale of fees for National Diploma Examinations be varied in the following way and, on the recommendation of the Examinations Committee, these received the approval of the Council:

	existing	*proposed*
Fee for each establishment	£15	£18 18s.
Fee for each examination paper in excess of six	£1 10s.	£1 15s.
Fee for each candidate	15s.	5s. per subject

Institution Examination Part III

The Council accepted a further recommendation of the Examinations Committee that in the present Part III Examination the optional subject 'Electronic engineering' be divided into two subjects, namely 'Physical electronics' and 'Applied electronics'. In the view of the Committee, the continuing developments in the field of electronic engineering are such as to make it impossible for a single examination subject, and its associated course of study, to cover the subject adequately.

The Council approved this recommendation and noted that the advice of the Electronics and Communications Section Committee would be sought on the detailed content of the two new special subjects.

Annual Report

The Council authorized the issue of the Annual Report, subject to certain modifications being made in the 'copy' prepared by the Drafting Committee. The report will be available to members in time for the Annual General Meeting of The Institution on the 19th May 1960, when it is to be presented.

Oversea Activities Committee

The Council approved the election of Mr. N. C. S. Kumar as Chairman of the Madras Oversea Committee in succession to Mr. R. Wright, who was retiring from India, and the appointment of Mr. J. C. Grant as acting Oversea Representative in East Africa during the absence on leave of Mr. A. O. Cosgrove from May to October 1960.

Propagation distortion in v.h.f. sound broadcasting

A short article based on an Electronics and Communications Section paper (3221) entitled 'V.H.F. sound broadcasting: subjective appraisal of distortion due to multipath propagation in f.m. reception' by R. V. Harvey, B.Sc., Associate Member. The paper was published individually in March 1960 and will be republished in Part B of the Proceedings. It was read before the Electronics and Communications Section on the 4th April 1960 at Savoy Place (see p. 320). The author is with the British Broadcasting Corporation.*

DISTORTION may be caused in f.m. broadcast reception if there is strong local attenuation of the most direct signal from the transmitter, either by an obstacle between it and the receiver or by misalignment of the receiving aerial. In such conditions, signals reflected from distant objects may form an appreciable fraction of the total signal reaching the receiver, and each will be delayed with respect to the primary signal by a time depending on the difference in the path lengths.

Effect of delayed signals

A typical delayed signal may have, for example, a path difference of 8 km; this can be expressed as 2400 wavelengths at a transmitter frequency of 90 Mc/s. In this case, the phase difference between the primary and delayed signals varies by four complete cycles as the transmitter frequency deviates between the limits of ± 75 kc/s in the course of an f.m. transmission. There will therefore be unwanted, rapid variations in both the phase and the amplitude of the received signal.

Since an f.m. receiver must respond to the rate of change of the phase of the signal, the distortion due to the added phase modulation is inevitable. On the other hand, the amplitude variation can be suppressed in the receiver by an efficient amplitude limiter; if it is not adequately suppressed, the distortion can be much greater than that due to phase modulation alone.

Visual display

The amplitude variation can be used to show the characteristics of the propagation path which the received signal has traversed. If the vertical deflection of an oscillograph is derived from the amplitude of the signal in the receiver and the horizontal deflection from the frequency-modulation output of the receiver, the trace will describe a stationary pattern representing a graph of amplitude versus frequency.

The relative amplitude and path difference of the principal delayed signals can be deduced from this pattern. For instance, in the example given above, there will be a roughly sinusoidal pattern showing four cycles when the transmitter is fully modulated. The relative amplitude is given by the ratio of the peak amplitude of the pattern to the mean displacement from zero.

* This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

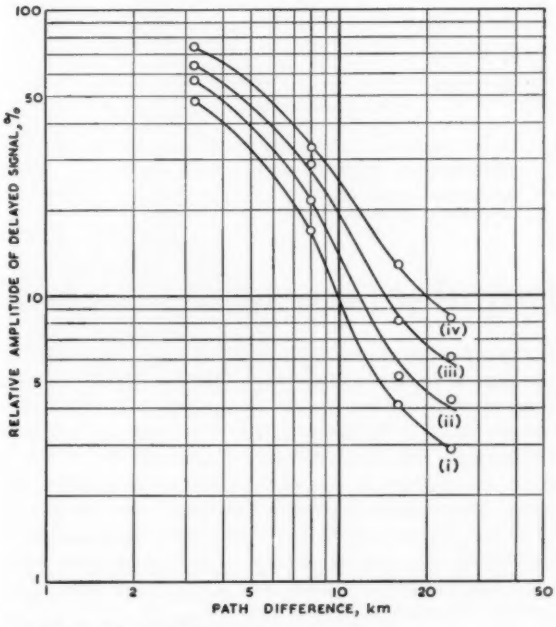
Type of distortion

Referring again to the typical example given above, the four cyclic changes in amplitude and phase occur during every half-cycle of the wanted modulation. The distortion spectrum then contains not only the eighth harmonic, but a number of harmonics over a wide range below and above the eighth.

Distortion of this type is most annoying to the ear, especially during programmes of music; piano music is particularly susceptible, and for this reason it was used in conducting subjective tests. The extent of the harmonic spectrum depends on the path difference of the delayed signal, giving a variety of effects, varying from the sound of an overloaded amplifier at low path differences to a hissing noise when the path difference is large.

Subjective tests

To determine the relative annoyance caused by the distortion arising from different conditions of the propagation path, it was necessary to perform tests in controlled conditions, using a number of listeners. Multipath propagation was simulated



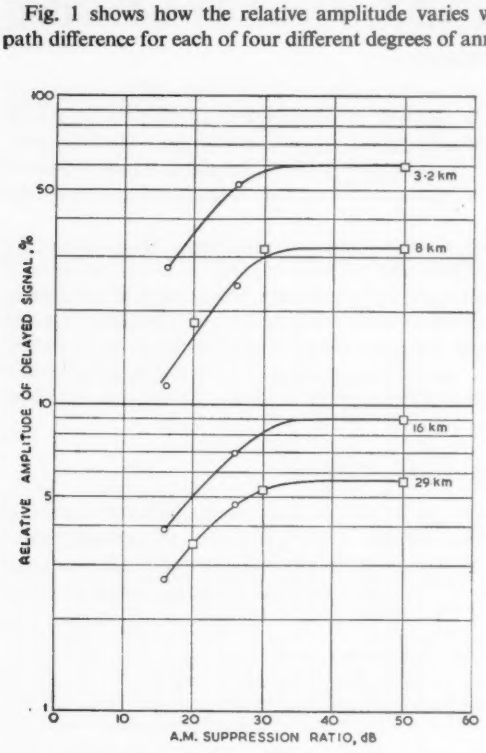
1 *Curves of equal annoyance*

(i) just perceptible
(ii) perceptible
(iii) slightly disturbing
(iv) disturbing

Modulation: piano music
Loudspeaker: high-quality unit
A.M. suppression ratio: 50 dB

in the laboratory using a tapped delay-line so that one delayed signal could be added to a primary signal with a relative amplitude of from 0 to 100% and an equivalent path difference of from 0 to 29 km.

Fig. 1 shows how the relative amplitude varies with the path difference for each of four different degrees of annoyance ranging from 'just perceptible' to 'disturbing'. The receiver used for this test had a high-quality loudspeaker and a very efficient amplitude-limiter. A similar test using a commercial receiver with a less-efficient limiter gave a similar set of curves at about half the delayed-signal amplitude shown here.



2 *Curves for slightly disturbing distortion, showing effect of increasing a.m. suppression ratio*

Modulation: piano music
Loudspeaker: high-quality unit

The striking feature of these curves is the rapid increase in the annoyance as the path difference increases. At the highest path difference, 29 km, a relative amplitude of only 3% is just perceptible with a virtually perfect receiver. Fortunately, signals of such large delay seldom reach this amplitude in practice; when distortion is experienced in f.m. reception, the delayed signal causing it usually corresponds to a path difference in the range 8–25 km.

Receiver design

To determine the efficiency of amplitude-limiting necessary to minimize the distortion, tests were made with receivers having different a.m. suppression ratios. This ratio is defined as that of the output due to 40% f.m. to that due to 40% a.m. when both are applied simultaneously. The result is shown in Fig. 2, and it is clear that a rapid improvement is gained by increasing the a.m. suppression ratio to 30 dB, but above 35 dB little further advantage is gained.

Of the two types of f.m. discriminator in common use, the Foster–Seeley type affords little suppression by itself and must be preceded by a limiter. The ratio detector, on the other hand, is designed to suppress a.m. but it can barely attain a suppression ratio of 30 dB in practice, and it is therefore desirable for extra limiting to be provided. A combined limiter and discriminator circuit has recently been developed* which is equivalent to a Foster–Seeley discriminator preceded by an efficient limiter, but has the advantage of not requiring the extra i.f. amplification associated with more conventional limiters.

621.391.812.7 : 621.396.621

* SPENCER, J. G.: 'F.M. receiver using new dynamic limiter', *Wireless World*, November 1959, p. 493

Impulse strength of impregnated-paper dielectrics

A brief article based on a Supply Section paper (3143) entitled 'The impulse strength of impregnated-paper dielectrics as used in high-voltage cables' by B. Salvage, B.Sc.(Eng.), Ph.D., Member, and J. A. M. Gibbons, B.Sc. The paper was published individually in December 1959 and will be republished in Part A of the Proceedings. It was read at Savoy Place before the Supply Section on the 9th March 1960 and a report appears on p. 320. Dr. Salvage is in the Electrical Engineering Department, Leeds University, and Mr. Gibbons is with the Central Electricity Generating Board. They were both formerly with W. T. Henley's Telegraph Works Co. Ltd.

In spite of the increasing use of plastics at low voltages, impregnated paper still remains practically unrivalled as a dielectric for oil-filled and gas-pressure cables designed to operate at voltages of 33 kV and above. Since the insulation thickness required in a pressure cable is governed primarily by the specified impulse test voltage, it is vitally important that cable manufacturers should employ papers and impregnants having properties which will ensure the highest possible impulse electric strength of the composite dielectric.

It will be appreciated that research into this problem would be slow and expensive if conducted on full-sized cables. Fortunately much valuable information can be readily obtained from experiments on model cables, work on actual cables being confined to confirmatory tests.

Properties of the paper

The most important physical properties of the paper affecting the impulse strength are the thickness, density and air impermeability. Experiments, which have been concerned solely with fully-impregnated-paper dielectrics, have shown that the impulse strength is increased when the thickness of the paper is decreased, and when the density, by itself, is

decreased, in accordance with the reduced permittivity of the dielectric and hence lower butt-gap stresses. An increase in the air impermeability produces no significant change in the impulse strength of a dielectric impregnated with a viscous compound but an appreciable increase with an oil or heated compound having a low viscosity.

Confirmatory experiments have been made on a length of 0·2in.^{2} single-core oil-filled cable insulated in four sections to a nominal thickness of 0·345in. In the first section a 3·2mil paper having a 'normal' density and air impermeability was used next to the conductor. In the second section a 2·5mil paper having the same density and a much higher air impermeability was employed, and in the third and fourth sections the same paper supercalendered to a thickness of 2·0mils to give an appreciably higher density and air impermeability was incorporated.

Two impulse breakdown tests were made on each of the four sections of the cable at ambient temperature, and the mean impulse strength of each section is shown in Table 1, allowance being made for the effect of permittivity grading in the dielectric where applicable, together with the corresponding impulse-strength measurements made on model cables. The results show the good agreement between the behaviour of model and actual cables and demonstrate the important advances in cable performance which have been achieved as the result of laboratory studies: the third section of the cable has a 31% higher impulse breakdown voltage than the first.

Table 1. Impulse strength of sections of 0·2in.^{2} single-core oil-filled cable and model cables

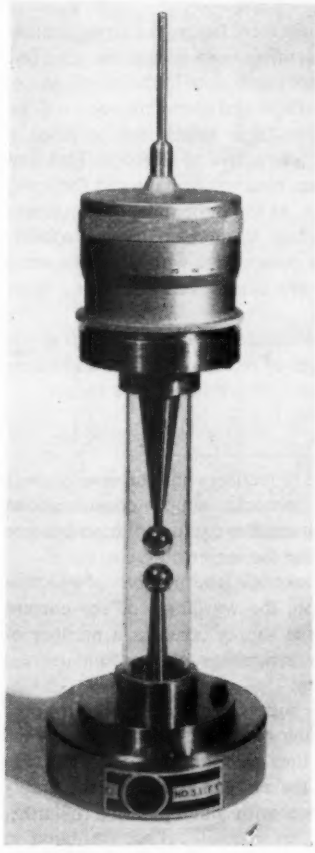
properties of paper			impulse strength		
			cable		
thickness	density	air impermeability	assuming uniform dielectric	allowing for permittivity grading	model cables
mils	g/cm^3	Emanueli units $\times 10^6$	kV/cm	kV/cm	kV/cm
3·2	0·82	1·3	990	—	1070
2·5	0·82	17	1180	—	1300
2·0	1·02	35	1300 1250	1220	1390

Impregnating oils and compounds

It is to be expected that the impulse strength of impregnated-paper dielectric should be closely related to that of its impregnant—the main reason for impregnating the paper is to increase its electric strength—and hence an investigation has been made into the impulse strengths of cable-impregnating oils and compounds. For this purpose a special test cell, which is shown in Fig. 1, has been constructed.

Of particular interest are the effects of the electrode gap and the temperature on the impulse strength. Over the range of electrode gaps corresponding to the paper thicknesses normally used in high-voltage cables, the impulse strength of all impregnants increases markedly as the electrode gap is decreased, the effect being very similar to that of the paper-tape thickness and hence butt-gap thickness in a lapped impregnated-paper dielectric.

For an electrode gap of 0·005in. and at 20°C, the impulse strength of oil-filled-cable oil is approximately 1400kV/cm, whereas the impulse strengths of rosin- and poly*iso*butylene-containing compounds are approximately 2100kV/cm. When the temperature is increased to 85°C the impulse strength of oil-filled-cable oil is practically unchanged, but the rosin- and poly*iso*butylene-containing compounds experience a considerable reduction, their impulse strengths becoming of the same order as that of oil-filled-cable oil. These temperature effects are very similar to those observed in cables and model cables.



1 *Oil test cell*

Conclusions

Our experiments lead us to the view that the impulse breakdown process in a fully-impregnated-paper cable dielectric is initiated in the impregnant at or near the conductor. Accordingly, the impulse strength of a cable is primarily dependent on the impulse strength of the impregnant, and the improvements which may be produced by varying the properties of the paper are due to the modifications in the breakdown processes in the impregnant which the changes in the paper cause.

621.315.211.048 : 621.317.333.8

Application of power rectifiers and convertors

A brief account of a Utilization Section paper (3215) entitled 'Some considerations in the application of power rectifiers and convertors' by J. P. McBreen, Associate Member. The paper was published individually in February 1960 and will be republished in Part A of the Proceedings. It was read on the 10th March 1960 before the Utilization Section at Savoy Place (see p. 322). The author is in the Heavy Plant Division of Associated Electrical Industries Ltd.

During the last 10–15 years there has been a large increase in the use of power rectifiers, and within the past few years two notable changes have taken place in their application.

The development of germanium and silicon monocrystalline semiconductor rectifiers of suitable rating has provided a more efficient and compact alternative to selenium–iron and mercury-arc rectifiers for most constant-voltage and for many variable-voltage applications. At the same time, improvement in grid-control techniques has made mercury-arc-rectifier-controlled d.c. motor drives competitive with Ward Leonard and a.c. motor drives for many applications, including those requiring reversal of power.

This changing pattern is illustrated in Table 1, which shows the present most suitable types of rectifier available and where appropriate gives an indication of possible future trends.

Supply considerations

With the growth in the use of rectifiers and the development of the a.c. supply system networks, supply considerations which affect the design of the rectifier equipment have become more important, especially for the larger ratings.

Depending on the pulse number (the number of effective phases) used for rectification, the waveform of the current drawn by a rectifier from the supply contains a number of harmonic currents, each a percentage of the fundamental supply current to the rectifier.

In passing through the supply system these harmonic currents induce corresponding harmonic voltages across the impedances through which they pass, and these in their turn are propagated throughout the associated parts of the supply network and could interfere with the operation of other consumers' equipment.

Whether or not such interference takes place depends on the magnitude of the harmonics, on the impedance and arrangement of the supply system, and on the construction of the apparatus liable to be affected by the harmonics. By suitable attention to any one of these, interference can be reduced to an unobjectionable level, but usually considerations of cost prevent any of them from reaching the ideal and a compromise is necessary.

Permitted rectifier loading on supply system

Where the rectifiers and the supply are concerned, this compromise is embodied in recommendations which the local supply authorities in the United Kingdom use as a guide when deciding what rectifier capacity to permit in a particular system. Basically the permitted rectifier loading is limited according to its pulse number and to the minimum operating short-circuit capacity (the impedance) of the system, as shown in Fig. 1.

This relationship is directly applicable only to rectifiers without grid control other than that required for occasional starting or small-range voltage control. When considering the supply to rectifiers with wide-range grid control of voltage, the increased harmonic content in the supply to such rectifiers has to be taken into account.

Table 1. Application range of semiconductor and mercury-arc rectifiers

application	rectifier type
industrial uses of various kinds where voltage control (if any) can be of moderate speed, e.g. factory and dock supplies, cranes, lifts, motor starting and speed control, exciters for large alternators, etc.	*medium and large sets:* germanium, silicon or multi-anode mercury-arc, depending on circumstances and voltage control. Increasing tendency to use germanium or silicon *small sets:* selenium
industrial uses requiring fast or sensitive voltage control or inversion, e.g. reversing-mill drives, winders, many auxiliary drives, paper machines, printing presses, field-forcing of large d.c. or a.c. machines, etc.	*medium and large sets:* multi-anode steel-tank mercury-arc *small and some special medium-sized sets:* single-anode (hot-cathode ignitron or excitron) mercury-arc
d.c. railway substations	multi-anode mercury-arc, germanium or silicon
50c/s locomotives and motor coaches, non-regenerative	silicon, germanium, or single- or multi-anode mercury arc. Increasing tendency to use silicon or germanium
as above but with regenerative braking	single- or multi-anode mercury arc
high-power electrolysis, e.g. for aluminium, copper, zinc, chlorine, hydrogen, etc.	**above about* 250 *volts:* germanium or silicon. *up to about* 250 *volts:* germanium
battery charging, electrolytic cleaning or tinning, electroplating	selenium, germanium or silicon, with increasing tendency to use germanium or silicon
mining services underground, d.c. electric furnaces, e.g. for titanium, and arc-welding	germanium, silicon or selenium
electrostatic precipitators, high-voltage d.c. testing equipment	*usually selenium, but may be silicon in future
anode supplies for radio transmitters	usually special single-anode mercury-arc, but may be silicon in future
nuclear research, usually involving high-power switching or inversion	special mercury-arc, usually single-anode

* Although there are many existing mechanical rectifiers in these applications, it is unlikely that others will be provided in the future because of the outstanding advantages of semiconductor rectifiers for such duties

Power demands

In the case of rectifier-controlled d.c. motor drives having a frequent reversal or starting duty, there is a further and often more critical limiting relationship between the rectifier rating and the supply-system capacity. The motor-starting current for such drives is usually two or three times the nominal full-load current and, as the power factor of a grid-controlled rectifier is reduced in proportion to any reduction in voltage by grid control, starting up such drives from standstill imposes large reactive-power demands on the supply system.

Supply-system impedances are usually predominantly reactive, and therefore such fluctuating reactive-power demands must cause a corresponding percentage fluctuation in the supply-system voltage of approximately:

$$\frac{Q_2 - Q_1}{S + Q_2} \times 100$$

where Q_1, Q_2 are the reactive-power demands and S is the system short-circuit capacity.

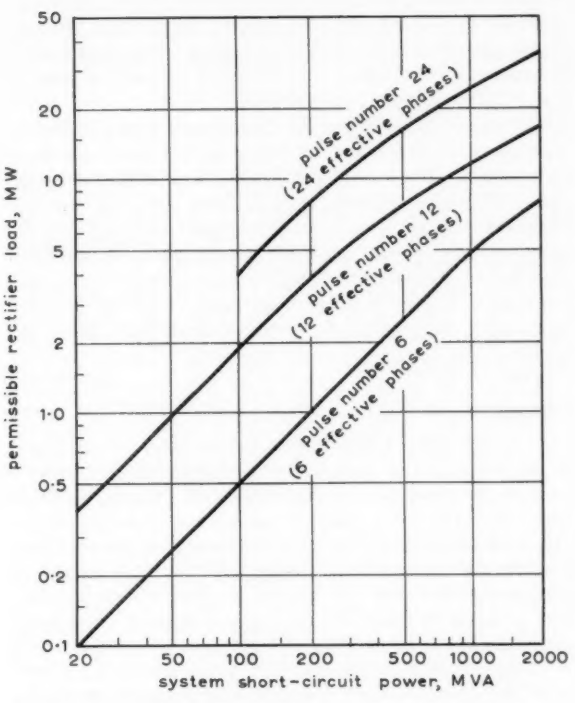
The greater the fluctuation and/or the frequency of the fluctuation in the supply voltage caused by such loads, the greater is the risk of producing annoying lamp flicker in lighting installations on the same system.

Low-temperature limitations

The increase in the use of grid control with mercury-arc rectifiers has emphasized their low-temperature limitations. B.S. 1698: 1950 states that the minimum temperature of rectifiers for satisfactory ignition shall be not less than 5°C and for the application of full load not less than 10°C.

Present-day duties require the application of up to three times full load with the voltage suppressed to zero by grid control. For the satisfactory performance of such duties a minimum rectifier temperature of about 20°C, with strict maintenance of the correct temperature differentials between the rectifier anodes and condensing zone, is necessary.

621.314.6



1 *Curves relating rating and pulse number of rectifier installation to system short-circuit capacity. Source: Central Electricity Authority Engineering Recommendations G5/1*

M.K.S. formulae for electromagnetism

A short account of a Measurement and Control Section paper (3012) entitled 'Development of the formulae of electromagnetism in the M.K.S. system' by P. Vigoureux, D.Sc., Associate Member. The paper was published individually in July 1959 and will be republished in Part B of the Proceedings. It was read on the 2nd February 1960 at Savoy Place before the Measurement and Control Section (see p. 321). The author is at the National Physical Laboratory.

The effect of the change from the C.G.S. systems of electric units to the International system, also known as Giorgi or M.K.S. system, on the teaching of electromagnetism has been frequently discussed at meetings and in scientific journals. Many have maintained that it has made teaching more difficult, especially to beginners.

The difficulty may have arisen through enthusiasts taking the opportunity of the introduction of the M.K.S. system to change and as they think reform the methods of teaching, abandoning the notions of magnetic poles and at first even of point charges for those of magnetic and electric force and flux.

While there are many ways of developing the theory of electromagnetism, it is by no means true that the method used in the older treatises, e.g. by Maxwell or Jeans, and by some modern authors, e.g. Astbury or Bleaney and Bleaney, has become less satisfactory because lengths and masses are now expressed in metres and kilogrammes instead of in centimetres and grammes or because the magnetic and electric constants of vacuum are not taken to be unity as formerly.

In the paper a method of development based on the internationally agreed definition of the ampere is presented. The scope is confined to outlining a procedure which seems reasonable for teaching beginners who are supposed to be familiar with trigonometry but not calculus.

Magnets

Experiments with magnetized needles show that a long thin magnetized body behaves as though it had magnetic 'poles' Φ, $-\Phi$ at the ends and that the repulsive force between poles Φ, Φ' a distance r apart is equal to $k\Phi\Phi'/r^2$ where k is some constant. It is convenient for reasons which will become clear as we proceed to write k in the form $1/(4\pi\mu)$; and with the units in which magnetic quantities are normally expressed μ is $1{\cdot}257 \times 10^{-6}$.

The notions of magnetic potential, magnetic field strength, magnetic flux and flux density follow in the usual elementary way. Indeed with a unit pole giving rise to unit flux a simple notion of Gauss's theorem does not seem excluded even for beginners, nor do the concepts of magnetic doublet, magnetic moment and magnetic shell. The potential due to a doublet, that due to an element of shell, and an expression for the potential of a shell in terms of its strength and of the solid angle subtended can all be derived without the use of the calculus.

Currents

A second series of experiments demonstrates the similarity in the behaviour of coils carrying electric currents and of magnets; in particular the experiments are planned to illustrate the action of a magnetic field on a current and the magnetic force produced by a current. It does not seem possible for beginners not conversant with the calculus to deduce the law:

$$H = \frac{I \sin\theta \, ds}{4\pi r^2}$$

from the formula for the potential of a magnetic shell. The best that can be done is to show them that when this law is applied to simple cases it agrees with results obtained in a more elementary way, e.g. for the field strength at the centre or on the axis of a circle.

The beginner can also be shown how to calculate the field strength inside an infinite solenoid or near an infinitely long straight wire from the expression for the potential of a shell, but he would not be able to apply the above formula to these cases.

The corresponding expression:

$$F = \mu IH \sin\theta ds$$

can be obtained from the first by simple processes, and it leads to the force per unit length between two parallel wires. The definition of the ampere is now introduced and provides a check of the value stated before for μ.

Electric charges

The law of force between electric charges is deduced from experiments similar to those performed before with magnets, but the experiments are simpler because electric charges exist singly. Here again it is necessary to introduce a constant $1/(4\pi\epsilon)$ and to explain that with the unit of charge in common use ϵ is $8{\cdot}85 \times 10^{-12}$. The notions of electric field strength and electrical potential follow as for magnetism, and lead to experiments with condensers, discharge through galvanometers, and identification of rate of change of charge with electric current.

Law of induction

Whatever may be thought of the validity of deducing electromagnetic induction from the mutual energy of a magnet and a loop of current, the argument is not suitable for beginners. Faraday's experiments on induction must be used to prove proportionality between the electromotive force e and $-\partial N/\partial t$. Moreover as induced e.m.f. and difference of potential can be shown by simple experiments to act in the same way to produce electric current, they can be identified; finally, quantitative experiments can be used to establish the equality of V and $-\partial N/\partial t$.

With the limitations put on the permissible level of mathematics it does not seem possible to go much further. Maxwell's equations and wave propagation cannot be derived without the calculus, and in consequence the beginner cannot be shown how to check the value of ϵ. But this limitation is precisely the same as in the C.G.S. systems where he has to accept the (for him) surprising statement that the ratio of the unit of electric potential to that of e.m.f. is equal to the velocity of light. It does not seem any worse to ask him to accept that the velocity is equal to $(\epsilon\mu)^{-1/2}$. 621.3.011.1

Electricity in the manufacture of hydrogen peroxide

A brief account based on a Utilization Section paper (3196) of the above title by B. E. A. Vigers, M.A., A.M.I.C.E., M.I.Chem.E., and R. O. Fletcher, B.Sc., A.M.I.Mech.E., Associate Member. The paper was published individually in February 1960 and will be republished in Part A of the Proceedings. It was read at Savoy Place on the 18th February 1960 before the Utilization Section; a report of the meeting appears on p. 322. The authors are with Laporte Chemicals Ltd.

ALTHOUGH most engineers will have some knowledge of the use of hydrogen peroxide as an industrial bleaching agent and as a highly compact source of energy for various propellant devices, they may not be so familiar with the methods of production. Until the establishment of the electrochemical process in 1908, the preparation of hydrogen peroxide remained that of the action of an acid on barium peroxide, as discovered by Louis-Jacques Thénard in the early 19th century. Recently there have been developed alternative processes using organic compounds which have certain economic advantages, particularly in regard to saving in electricity costs.

Commercial electrolytic process

The electrolytic process is of particular interest to electrical engineers because of the large usage of electricity and the

opportunity it gives for private generation of a part of the power requirements.

Direct formation of hydrogen peroxide in an electrolytic cell is not possible in usable quantities but peroxy compounds can be formed at the anode which by subsequent hydrolysis will yield hydrogen peroxide. The electrolyte in common use consists of ammonium bisulphate and sulphuric acid in solution with water, and the over-all reactions of the process may be represented by the following formulae:

In the electrolytic cell

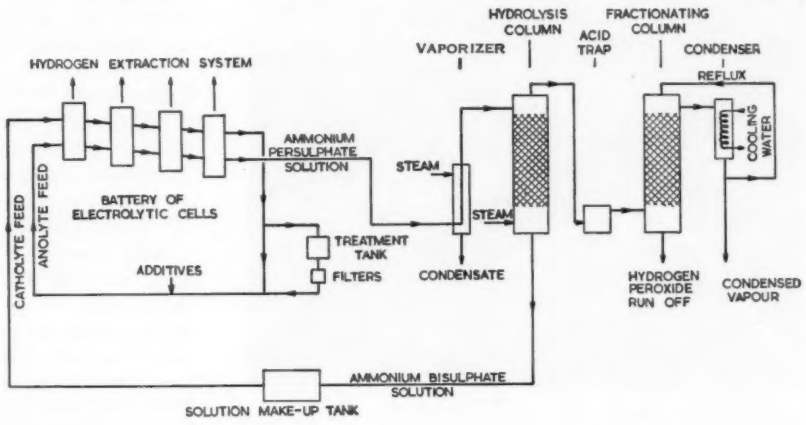
$$\underset{\text{ammonium bisulphate}}{2NH_4HSO_4} \rightarrow \underset{\text{ammonium persulphate (at anode)}}{(NH_4)_2S_2O_8} + \underset{\text{hydrogen gas (at cathode)}}{H_2\uparrow}$$

In the hydrolysis column

$$(NH_4)_2S_2O_8 + H_2O \rightarrow 2NH_4HSO_4 + \underset{\text{hydrogen peroxide}}{H_2O_2}$$

Fig. 1 is a simplified flow diagram of the process, from which it is seen that the ammonium bisulphate re-formed at the hydrolysis stage is returned as feed to the electrolytic cells. There are advantages in the use of a double-flow cell in which the electrolyte is first passed through the cathode compartment and then returned as feed to the anolyte side.

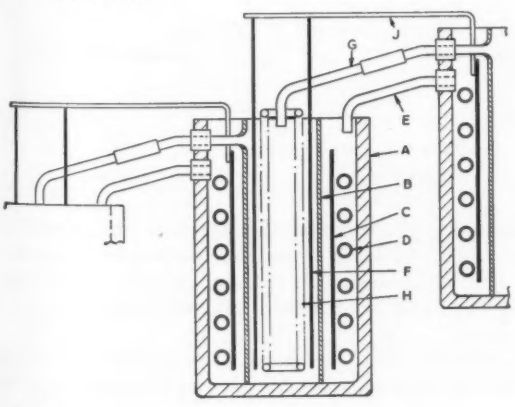
Fig. 2 shows a section through a typical cell using lead cathode and platinum anodes, and in practice there are several of these assemblies connected in parallel installed in each stoneware bath. A battery of these cells is generally arranged in a cascade formation consisting of 25 baths, and four such cascades connected in electrical series allow for operation at 500 volts. The general appearance inside a battery house is shown in Fig. 3.



1 *Liquor flow diagram for ammonium persulphate process*

2 *Section through a typical cell*

A stoneware bath
B ceramic diaphragm
C cathode
D cooling coil
E catholyte feed
F anode
G anolyte feed
H anolyte cooling coil
J series electrical connection



Electricity supply to batteries

For a typical factory, producing the equivalent of 8000 tons per annum of hydrogen peroxide at 100% strength, the total works load is 12MW, of which 3MW is obtained by private generation and the remainder imported from the public supply.

Over 90% of the electricity is used in the batteries, which are supplied from mercury-arc rectifiers, most of which are of the pumpless steel-tank design with delta/quadruple star transformers connected to the main 6kV switchboard. The first four rectifier units are in parallel operation with a d.c. generator and carry the load of 16 cascades, since this arrangement allows the generator output to be adjusted in accordance with steam demand rather than the battery current.

The remaining ten rectifier units are connected individually to separate battery units and use direct switching on the h.t. side, thus saving on the cost of heavy d.c. switchgear. Automatic voltage control is installed on the d.c. output, and in some cases automatic current control is utilized with considerable advantage in obtaining steady operating conditions at the battery.

Private generation

Apart from electricity the main services in the typical plant are steam at 5lb/in.^{2} (gauge) for distillation, and water

3 *The battery house*

for cooling batteries and condensing equipment on stills. Steam consumption averages 60000 lb/h, and since this occurs at the same time as the 12 MW electrical load it offers an ideal opportunity for back-pressure generation. Two turbines are installed for this purpose, one rated at 1 MW driving a 500 volt d.c. generator and the second rated at 2·5 MW driving a 6 kV alternator. Investigation of the capital and running costs shows that this system results in an annual return of 30% on the capital invested in the power plant and h.p. boiler-house.

Future trends

In contrast to general industry where the electricity charges are only a small fraction of the total production cost, the electrolytic production of hydrogen peroxide uses electricity as the basic requirement, and this can account for up to 50% of the total cost.

Although economies are brought about by partial private generation, the electrolytic process in this country is at a disadvantage compared with that in countries having hydro-electric power or special tariffs for similar applications. The result has been that other methods of producing hydrogen peroxide are being developed on a large scale, and these may finally supersede the electrolytic process in spite of its many attractive features. 621.357.1

Electro-mechanical transducers

A short account of a Graduate and Student Section paper with the above title by W. A. McCartney, Graduate. The paper was read before the Northern Ireland Graduate and Student Section at Belfast on the 16th December 1958 and was awarded a premium by the Council. The author was formerly with Short Brothers and Harland Ltd. and is now with James Scott and Co. Ltd.

In the design of servomechanisms it is often necessary to incorporate electrical signals which are functions of mechanical changes occurring within the system. These signals are obtained by using transducers to convert mechanical displacements into voltages.

Fig. 1 illustrates a common use for a transducer in a servo-control system. The output shaft is driven by the servomotor which is at rest only if $V_O = V_I$. Any change in input position I is followed by the output position O until both are aligned.

It will be appreciated that the transducers must have high sensitivity and the ability to generate the required transfer function accurately over a given range. Friction is also undesirable, and spurious noise should be negligible.

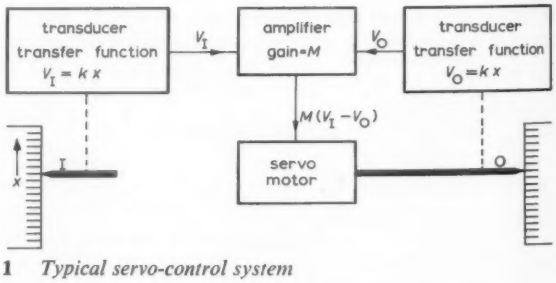
Transducers are available for measurement of velocity and acceleration, but as these are time-derivatives of length the paper deals only with displacement transducers, such as the potentiometer and the a.c. pick-off.

Potentiometers

The potentiometer is the most common transducer in present use and consists of a length of resistance element with a point contact or wiper movable along the entire length. Fig. 2 shows how this arrangement may be used to produce various transfer functions.

Linearity, resolution and residual noise

The linearity of a transducer is its ability to provide a voltage proportional to a particular function of input position over a given range. In precision potentiometers the linearity can be made accurate to within 0·1% when no current is drawn from the wiper. Loading will of course upset the linearity, but this can be remedied to a considerable extent by increasing V_I by 50% and inserting a resistance, equal to half the total resistance of the potentiometer, in series with the live end of the input.



1 *Typical servo-control system*

Resolution noise consists of step variations in voltage caused by the wiper being insensitive to displacements of less

than the distance between consecutive winding turns. Residual noise is the name given to spurious voltages generated by the movement of the wiper across the resistance element and is attributed mainly to variations in contact resistance.

Carbon potentiometers have excellent resolution but are normally unsuitable for servo applications owing to poor linearity and high residual noise.

Friction

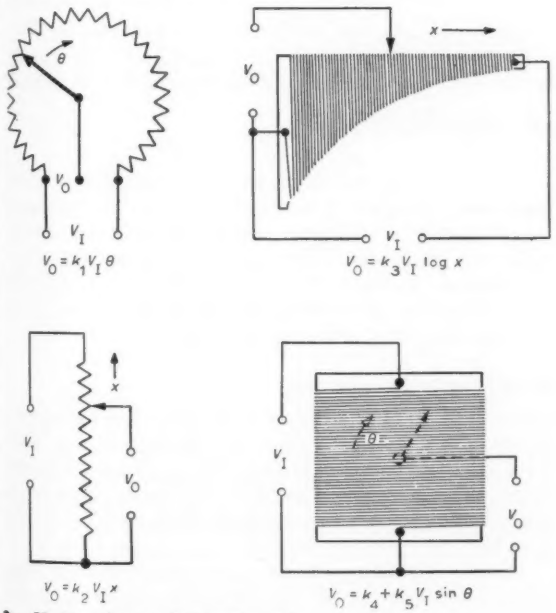
In a potentiometer, friction is governed by the force necessary to maintain adequate contact between wiper and element, especially in dynamic conditions. The wear caused by friction determines potentiometer life and is of paramount importance in continuously operated devices.

Because of these inherent defects in potentiometers it was found desirable to produce a sensitive, yet rugged, low-friction transducer, and this led to the development of the a.c. pick-off.

The a.c. pick-off

This transducer uses a differential transformer to convert displacement into voltage. Fig. 3 illustrates the arrangement which was designed so that the magnetic-circuit reluctance varies as a linear function of armature position. The input voltage is alternating, and it is assumed here that the magnetic flux linking coil 2, which has N turns, is sinusoidal.

When the armature is central, $\Phi_1 = \Phi_3$ and V_2 is theoretically zero. In practice however a few millivolts are generated owing to the quadrature component of flux caused by armature eddy currents. This effect is reduced to a negligible amount by slotting the armature as shown.



2 *Various forms of potentiometer*

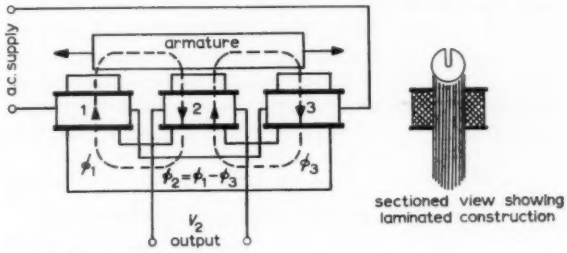
When the armature is moved to left of centre:

$$\Phi_1 > \Phi_3 \text{ and } V_2 = N\frac{d}{dt}(\Phi_1 - \Phi_3)\sin \omega t$$
$$= N\omega(\Phi_1 - \Phi_3)\cos \omega t$$

When the armature is moved to right of centre:

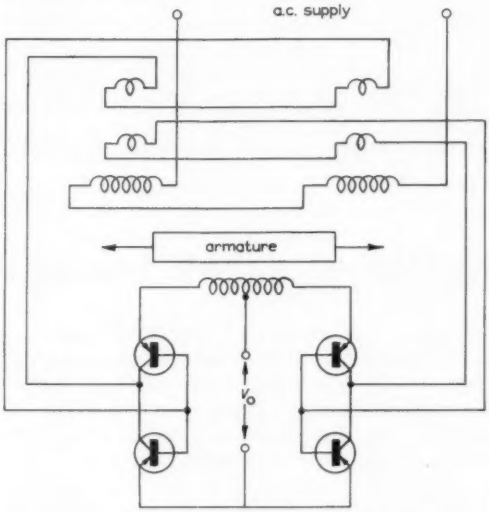
$$\Phi_1 < \Phi_3 \text{ and } V_2 = N\frac{d}{dt}(\Phi_3 - \Phi_1)\sin \omega t$$
$$= N\omega(\Phi_1 - \Phi_3)\cos(\omega t + \pi)$$

The output voltage is then proportional to displacement from centre and reverses phase when crossing zero. A more useful output is a direct voltage which changes sign when the alternating voltage reverses phase, and the transducer utilizes a transistor demodulator to achieve this effect.



3 *Differential transformer*

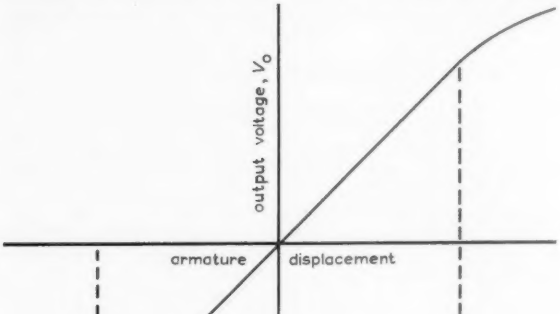
4 *The a.c. pick-off*



A transistor can be switched off and on by alternately biasing the base +1 volt and −1 volt with respect to the collector, although it is necessary to employ two transistors to isolate the bias voltage (see Fig. 4).

On gating the output voltage through transistors which are switched in synchronism with the supply frequency, the output V_O will consist of either positive or negative half-cycles of V_2,

depending on the direction of armature displacement from centre. Coil 2 is centre-tapped to provide a full-wave phase-sensitive output via two transistor gates, the bias voltages for



5 *D.C. characteristic*

which are obtained from secondary windings on the outer limbs of the core, connected so that constant r.m.s. bias is maintained irrespective of armature position. The pick-off operates from 115 volts 400c/s and gives a transfer function of $V_O = 300$ volts/in. over $\pm 0{\cdot}025$in. A typical d.c. characteristic is illustrated in Fig. 5.

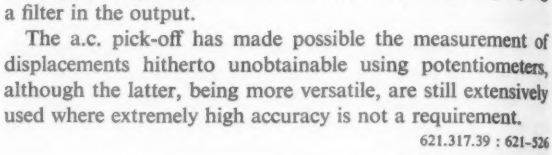
The unit is encapsulated in epoxy resin under vacuum, and Fig. 6 shows a pick-off which was designed for use as a valve-displacement transducer in electro-hydraulic servo-systems. The two armatures enable either translatory or rotary displacement to be measured with the same unit.

In this type of transducer, linearity depends mainly on machining tolerances of the mechanical parts. Attractive features are infinite resolution, comparatively low friction, and isolated output. One slight disadvantage is ripple at twice the supply frequency, but this can be overcome by employing a filter in the output.

The a.c. pick-off has made possible the measurement of displacements hitherto unobtainable using potentiometers, although the latter, being more versatile, are still extensively used where extremely high accuracy is not a requirement.

621.317.39 : 621-526

6 *A.C. pick-off (E-core) with linear and rotary armatures*



Protection of 132kV transmission systems

A short account of a Graduate and Student Section paper with the above title by Fl.-Officer D. Marshall, Graduate. It was read at Leeds on the 11th March 1958 before the North Midland Graduate and Student Section and was awarded a premium by the Council. The author was formerly with the Central Electricity Generating Board and is now in the Royal Air Force.

THE Grid system introduced after the 1926 Electricity Act provided a stable and secure supply with unification of frequency and the interconnection of generating stations on a national basis. A marked rise in the system fault level accompanied the increase in security of supply, and it became imperative to isolate system faults rapidly in order to avoid damage to plant, loss of system stability and possible danger to life.

This summary reviews the practice followed in the Yorkshire Division of the Central Electricity Generating Board.

The aim of a protection scheme is to detect the presence of a system fault and then to eliminate it by isolating the faulty equipment. The Grid system is divided into discrete units, e.g. a feeder or a transformer-feeder, and each unit is fitted with 'unit protection' which operates for all internal faults and remains inoperative for external or 'through' faults. This main protection is normally backed up by 3-phase overcurrent relays as an additional safeguard.

Feeders up to 12 miles long

It is usual to protect feeders up to about 12 miles long by means of a differential system. Circulating-current schemes have not been installed in the Division; the Casson–Last phase-comparison system has been tried but, as it is prone to maloperation in heavy through-fault conditions, it is unlikely that the scheme will be continued.

Balanced-voltage systems using privately owned pilot-wires are well established but are not used unless the pilot-wires are already available. The DSC method which uses pilot-wires

rented from the General Post Office has been installed on a number of feeders. It is essential to monitor continuously the G.P.O. pilots for open-circuits, short-circuits and crossed wires. The phase-fault setting is normally greater than 100% full-load current to prevent maloperation should the pilot-wires become short-circuited. This scheme is in the high-speed category, having an operating time of approximately 60millisec.

Feeders over 12 miles long

For feeders over 12 miles long it becomes technically and economically advantageous to install a distance-measuring rather than a pilot-wire differential system. It is not practicable to arrange for normal distance-measuring schemes to have a high operating speed for the whole length of the feeder. The high-speed zone is usually restricted to 80% of the feeder length, the remainder having a longer fault-clearance time.

Owing to the undesirability of long fault-clearance times, the longer transmission lines are protected by a phase-comparison scheme using high-frequency carrier currents transmitted over the primary lines. Low-speed distance protection has been in service for many years and has been extremely reliable. High-speed distance protection now installed is of either the DZ or the ratio-balance type.

Phase-comparison carrier-current schemes of the telephase type are installed on long lines, using frequencies ranging from 80 to 800kc/s. There is continuous monitoring of all valve circuits, and comprehensive test facilities are provided. The equipment has an operating time of approximately 3 cycles and, working in conjunction with modern bulk-oil or air-blast circuit-breakers, fault-clearance times of 4 cycles have been experienced.

Transformer-feeders

At area-board supply points it is economical to eliminate the expensive h.v. circuit-breakers on the 132kV side of the transformers. The feeder is then protected from the h.v. side by a single-step distance scheme; there are no discrimination difficulties, as the relays are set to 'look' halfway into the transformer (which corresponds to about 50 miles of transmission line). Faults fed from the l.v. side are detected by directional-overcurrent relays 'set down' to about 50%, 0·2 T.M.

The transformer is protected by a biased-differential scheme, incorporating restricted-earth-fault protection on both windings, together with the usual Buchholtz and winding-temperature devices.

When the fault causes the l.v. circuit-breakers to open, intertripping of the distant h.v. circuit-breakers must be arranged. It is a tribute to the reliability of modern protection that it is sometimes permissible to switch a fault onto the h.v. side of the transformer deliberately ('fault throwing') to effect this intertripping by operation of the distance protection on the feeder.

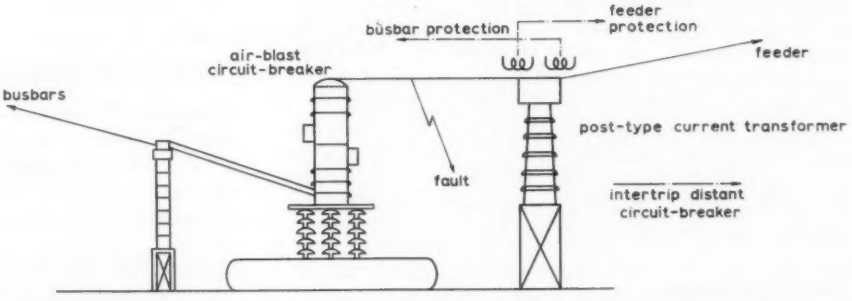
Busbars

Circulating-current systems with additional check features to guard against maloperation are used to protect busbars. Earth-fault protection only is usually installed, as the phases are segregated and a fault free of earth is unlikely. To clear circuit-breaker faults on air-blast breakers, the breaker at the distant end of the feeder may have to be tripped. The intertripping is usually achieved by unstabilizing the feeder main protection (Fig. 1).

Future trends

Over the past two decades the main development in protection engineering has been in the quest for high operating speeds. Fault-clearance times of 6 cycles are not now uncommon and there is little danger to system stability. The principal trend in the future will probably be in the development of 'static' relays which make use of electronic techniques and terminate in a slave relay; this would eliminate the sensitive mechanical relay, and all comparisons would be electrical rather than mechanical in nature.

It is becoming usual to install fault-recording apparatus, and information about the system conditions for the 25 cycles prior to the inception of a fault may be recorded. The average fault incidence for overhead transmission lines per 100 circuit-miles is 2·05 per year. Of these, 85% involve the breakdown of insulation between one phase and earth, and 48% of the faults can be attributed to lightning.



1 *Busbar protection with post-type current transformers*

The extent to which the ideal requirements for the protection of plant can be fulfilled is determined by economic as well as technical considerations. The capital cost of protection can be regarded as the premium paid for insurance against the severe consequences of failure to clear a system fault.

621.316.91

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available in due course

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Electrical units and standards

A synopsis of a Review of Progress (paper 3242) with the above title by P. Vigoureux, D.Sc.(Eng.), Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the National Physical Laboratory.

THE eight years since the publication of the last Progress Review on this subject have witnessed three investigations of great importance for the future of electrical units and standards: first, atomic beams have been used, notably at the National Physical Laboratory, England, to measure frequency far more accurately than had ever been done before; next, a physical constant, the gyromagnetic ratio of the proton, has been measured at the National Bureau of Standards, U.S.A., also more accurately than had been done before; and finally the National Standards Laboratory, Australia, has developed an alternative to the hitherto universal use of inductance as the fundamental standard from which the unit of resistance is derived for accurate work.

Atomic beams

The atomic beam of the N.P.L. acts as a resonator whose frequency depends only on the difference between two energy states of the caesium atom. A collaboration over three years, during which the U.S. Naval Observatory was responsible for the astronomical observations and the N.P.L. for the provision of time based on the frequency of the caesium-beam resonance, has resulted in the latter being determined as 9192631770 $\pm$ 20c/s of ephemeris time.

But astronomical observations, even averaged over many years, cannot yield the accuracy of 1 part in 10^{10} with which the frequency of the caesium beam can be compared with laboratory standards, e.g. quartz oscillators, in 10min, and the solar and heavenly systems are subject to changes which, as far as we know, are not suffered by atomic processes.

There is therefore a possibility that at some future date the second of time may be defined in terms of the frequency of an atomic radiation, on the same principle that the metre will shortly be defined in terms of the wavelength of another such radiation, the orange line of krypton 86.

Gyromagnetic ratio

The angular frequency of the Larmor precession of protons in a magnetic field H is equal to γH where γ is the gyromagnetic ratio. The National Bureau of Standards has measured this constant by observing the frequency of free precession in a field produced by a known current in a coil of known linear dimensions, and has obtained a preliminary value of 336·167m/As.

It can be argued that, as frequency can be measured more accurately than mechanical force, and as the field at the centre of a solenoid is less affected by errors in diametral dimensions than is the force between coils, the determination of gyromagnetic ratio is capable of greater reproducibility than that of current defined as at present from the force between straight parallel wires.

It is thus possible that in the course of years yet another physical constant might form the basis of the definition of our system of units, leaving only the unit of mass fixed by a material prototype.

Capacitance

The third of these remarkable developments started at the National Standards Laboratory by the proof that in certain conditions the capacitance between opposite segments of a cylinder divided into four segments is proportional to the length of the cylinder but is independent of any other dimension.

Hitherto the establishment of the units of resistance and capacitance has been based on calculable standards of self or mutual inductance; but, since the velocity of light is now known to closer than 1 part in a million, the above theorem provides an independent check on the unit of resistance. Indeed it appears that the new procedure may turn out to be five or even ten times more accurate than the old; if these estimates and those relating to the determination of the gyromagnetic ratio of the proton prove correct, it will become possible to make 'absolute' measurements of the electrical units to nearly the same accuracy that they can be maintained by standard resistors and cells.

It thus appears that we are witnessing a change in the position of electrical units and standards the like of which has not been seen since F. E. Smith and his collaborators some 50 years ago laid the foundations of accurate determination and maintenance of units by their work on the current balance, the Lorenz apparatus, standard cells, voltameters and mercury resistors.

621.3.011 : 389.6(100)

Transistor characteristic frequencies

A synopsis of a Measurement and Control Section paper (3206) entitled 'Measurement of transistor characteristic frequencies in the 20–1000 Mc/s range' by J. Bickley, B.Sc.(Eng.), Graduate. The paper is published this month in Part B of the Proceedings. The author is at the Services Electronics Research Laboratory.

THE author describes apparatus for the rapid determination of the cut-off frequencies f_1 and f_α of transistors in the 20–1000 Mc/s range. Accurate measurements at these frequencies are made possible by the application of transmission-line techniques to the method of comparing the high-frequency voltages which appear across small resistors connected to two leads of the transistor.

Methods are adopted which separate the measuring circuits from the input circuit and make the design of the latter

non-critical. The relative accuracy of f_1 and $_\alpha$ measurements is discussed, and it is concluded that the inherently more accurate f_1 measurement should have an error within $\pm 5\%$, whereas the error in f_α is probably 2–3 times larger. A few typical measurements are given. 621.317.61 : 621.382.3

Bandwidths of variable-reactance amplifiers and convertors

A synopsis of an Electronics and Communications Section paper (3224) entitled 'Comparison of gain, bandwidth and noise figure of variable-reactance amplifiers and convertors' by J. D. Pearson, M.Sc., and J. E. Hallett, Graduate. The paper is published this month in Part B of the Proceedings. The authors are with Ferranti Ltd.

THE authors derive formulae for the gain-bandwidth products and noise figures of a variable-reactance amplifier and a convertor, and show that for equal gains and noise figure the convertor has a greater bandwidth than the amplifier. This is confirmed experimentally with a circuit operated as a straight amplifier and a convertor. 621.375.9

Characteristics of tape structures

A synopsis of an Electronics and Communications Section paper (3229) entitled 'A simple method for predicting the characteristics of tape structures' by J. Allison, Ph.D., B.Sc.(Eng.), Graduate. The paper is published this month in Part B of the Proceedings. The author is in the Department of Electrical Engineering, University of Sheffield.

THE author describes a method for calculating the dispersion characteristics and coupling impedance of a Karp-type slow-wave structure. The structure is regarded as a ridge waveguide, periodically loaded with short-circuited stub lines. The analysis is simple and lends itself to the speedy assessment of the performance of a particular circuit.

Measurements on 8 and 4 mm experimental backward-wave oscillators are described and are shown to verify the usefulness of the approximate theory. These results are also compared with those obtained by field-theory analyses.

621.372.81 : 621.385.632.3

Failure of mica capacitors

A synopsis of a Measurement and Control Section paper (3261) entitled 'Some mechanisms of failure of capacitors with mica dielectrics' by A. A. New, M.Sc., F.R.I.C., A.Inst.P. The paper will be published in Part B of the Proceedings. The author is at the Post Office Research Station.

DURING investigations of mica-capacitor failures of various equipments during the last ten years and studies to improve their reliability, many mechanisms of failure have been examined. The author describes and illustrates the principal features of the mechanisms, and summarizes them in tabular form for quick reference. Some methods of examination and dissection of these capacitors with the minimum loss of evidence are given in detail.

This work does not imply that the proportion of mica capacitors which fail in service is excessive. Some of the causes of failure would occur in other types of capacitor, perhaps to a similar extent. 621.319.4

F.M.C.W. radar

A synopsis of an Electronics and Communications Section paper (3264) entitled 'Analysis of a frequency-modulated continuous-wave ranging system' by A. J. Hymans, M.Sc., A.Inst.P., Graduate, and J. Lait, M.A. The paper will be published in Part B of the Proceedings. The authors are at the Royal Military College of Science.

SOME aspects of an f.m.c.w. radar with a sawtooth frequency sweep are considered. The exact beat note for a discrete target is calculated and its Fourier transform is obtained. A scheme previously given by Gnanalingam for producing a coherent system is shown to be only approximately valid, and an alternative method is proposed. The effect of Doppler shift on the return is discussed. Range discrimination is examined critically. 621.396.962.25

Non-linear filter, predictor and simulator

A synopsis of a Measurement and Control Section Paper (3270) entitled 'A universal non-linear filter, predictor and simulator which optimizes itself by a learning process' by Prof. D. Gabor, F.R.S., Member, W. P. L. Wilby, Ph.D., and R. Woodcock, Ph.D. The paper will be published in Part B of the Proceedings. Prof. Gabor is Professor of Applied Electronics, and Drs. Wilby and Woodcock were formerly in the Department of Electrical Engineering, Imperial College of Science and Technology, University of London. Dr. Wilby is now with J. F. Crosfield Ltd., and Dr. Woodcock with the Marconi Wireless Telegraph Co. Ltd.

A MACHINE is described which consists of a universal non-linear filter, which is a highly adaptable analogue computer, together with a training device. The analogue machine has 18 input quantities, of which it can compute in about 2·5 millisec 94 terms of a polynomial, each term containing products and powers of the input quantities, with adjustable coefficients, and can form their sum. The input quantities may be, for instance, 18 past samples of the values of a stochastic variable which is fed into the machine, and the result of the computation is an output function which contains 94 free variables.

The training device optimizes the output, by successive adjustment of the variable coefficients, until it has approached a target function, as closely as can be achieved with a polynomial of 94 terms, by the criterion of the least-mean-square error. 681.142 : 621.317.79

OBITUARY

THOMAS EDWIN ALGER

Thomas Edwin Alger who died on the 11th February 1960 was born in Newport, Monmouthshire, on the 24th June 1873 and was the third and last surviving son of the late Roland Alger who founded R. Alger and Sons. He was educated in Newport and at Abbey House School, Tewkesbury.

After receiving electrical training he joined the family business in 1890, which at that time was mainly general and furnishing ironmongers, cutlers and gunsmiths. In 1903 the ironmongery business was sold in order to concentrate on the fast-developing electrical installation business, which included the first electrical lighting plant at the Alexandra Docks, Newport, and the pioneer work for which that period called.

His father was a founder-member of the Electrical Contractors' Association which 'T. E. A.' joined in 1916. He was elected vice-chairman of the then South Wales Branch of the Association in 1919 and in 1921 on formation of the Cardiff Branch became its first chairman. In 1931 the Newport Branch became a sub-branch of Cardiff and he was elected its first chairman, remaining in that office for no less than 18 years. He held a lively and wide interest in the Association's affairs, as was evidenced by the fact that in 1918 he was elected a delegate to the London Sectional Board which then covered Wales. He continued to serve his fellow-members in that capacity for 31 years, first on the London Board and finally on the South Wales Sectional Board.

It was perhaps on the Association's Council that his influence was greatest. He was elected to the Council precisely one year after taking office in his branch in 1920. He served on the Council for an unbroken period of 40 years. He was elected National President in 1925–26, in which year he convened the first annual conference of the Association.

He was an original representative of the E.C.A. on the Electrical Fair Trading Council, from which position he retired in 1953. In that year also he retired from the Executive Committee of the Association after a term of 23 years. He was elected a Fellow in 1927.

As the contracting business developed he foresaw the growing demand for the supply of installation materials and equipment, and to meet this need he founded the company now known as Alger's Wholesale Supplies operating throughout South Wales.

He is survived by three sons.

He joined The Institution as an Associate Member in 1911 and was elected a Member in 1939. He served on the Western Centre Committee from 1919 to 1922 and was vice-chairman from 1937 to 1939 and chairman in 1939–40. J. V. H.

GEORGE DOUGLAS ARDEN

George Douglas Arden who died at Barton-on-Sea on the 15th January 1960 was born on the 24th August 1884. He was educated privately and received his technical education at Crystal Palace Engineering School, followed by four years' practical training as a pupil with Exeter Corporation electricity department. In 1906 he was appointed mains assistant to Southampton Corporation electricity department, where he remained for six years. This was followed by three years as mains engineer to Derby Corporation.

During the First World War he held a commission in the signals division of the Royal Engineers. He was mentioned in dispatches and was wounded in 1917. From 1918 to 1920 he was attached to the Air Ministry as assistant electrical engineer on works and buildings.

On leaving the Services he was appointed in 1920 chief electrical engineer to Ironside, Son and Co., London, consulting engineers, a position which he held until 1926. He then joined British Petroleum as chief electrical and power engineer at their Llandarcy works, where he remained until his retirement in 1951. During the whole of this period he was responsible for steam and power production and distribution throughout the refinery to meet the requirements of a considerably expanding programme of development. It is noteworthy that he took a keen interest in the training of apprentices and helped many young engineers to qualify.

Following his retirement he moved to Barton-on-Sea, where he quickly associated himself with the community life of the locality. In his early years he had shown interest in sport, especially in rowing and sailing, and also in tennis, badminton and golf. He was a member of Neath Rotary Club from 1942 to 1948. He made and kept many good friends. He is survived by his widow and two sons.

He joined The Institution as an Associate Member in 1921 and was elected a Member in 1949. He served on the Swansea Sub-Centre Committee from 1935 to 1938 and from 1943 to 1946, being chairman in 1945–46; and on the Western Centre Committee from 1944 to 1951, being chairman in 1950–51. On his retirement to Barton-on-Sea he associated himself with the Southern Centre and became Local Honorary Treasurer of the Benevolent Fund in 1953. He was appointed to the Court of Governors of the Benevolent Fund in 1959. J. W. E./J. E. B.

REGINALD AYTON

Reginald Ayton who died on the 7th May 1959 was born on the 24th August 1881. He was educated at St. Anne's School, Redhill, and at Bedford Modern School. He received practical training with Siemens Bros., Woolwich, and with Newcastle upon Tyne Electric Supply Co., studying part-time at Finsbury Technical College and at Woolwich Polytechnic. On the completion of his training he became district engineer with the latter company.

In 1907 he joined the County of Durham Electrical Power Distribution Co. as assistant to the electrical superintendent and in 1908 was appointed electrical superintendent. Three years later he went to Johannesburg for seven months to work in the chief engineer's office of the Victoria Falls and Transvaal Power Co.

His real interest in life was the Winchester Corporation electricity undertaking which he joined in 1911 as city electrical engineer. He brought the Winchester generation station very high in the efficiency tables for stations of that size on various occasions, and in the early 1920's introduced the then scarcely known 'Olipel' ripple control for street lighting. He retired in 1946.

He was an austere, grave man, yet strangely likeable with a strong personality. He drove hard bargains with manufacturers and contractors alike because of his rigid insistence on perfection, but was always fair and consequently respected throughout the industry. An avid reader, 2–3 a.m. being a very normal retiring hour, his knowledge of many subjects was quite profound. He wrote to many people on subjects that interested him, but there seldom were personal contacts. At the time of the First World War he became quite an authority on beekeeping with a particular interest in the importation of Italian queen bees. He was keenly enthusiastic in model railway engineering and during his retirement built a 5in.-gauge dockside shunting locomotive.

He joined The Institution as an Associate Member in 1911 and was elected a Member in 1920. He served on the Hampshire Sub-Centre Committee in 1929–30. H. E. L.

CARL LOTHERINGTON GLEN-BOTT

Carl Lotherington Glen-Bott, O.B.E., M.A., who died in 1959 was born on the 20th May 1883. He was educated at Rossall School and at Cambridge University, followed by an apprenticeship with Siemens Bros., Stafford, on the completion of which he became a technical assistant with the company.

In 1908 he joined the Admiralty as a wireless-telegraph engineer engaged in research and development on wireless-telegraph equipment, first in H.M.S. *Vernon* and then from 1917 to 1940 at H.M. Signal School, Portsmouth. At the end of the First World War and with the introduction of silica-transmitting-valves development in the Signal School, considerable changes were made in the design of wireless-telegraph equipment, and he was then appointed principal technical officer and later chief technical officer of the establishment. In 1943 he was transferred to London, where he remained until his retirement in 1948.

In the execution of his duties, his aim was perfection. He set an example of care and thoroughness which was beneficial to all with whom he was associated. He was respected by all his colleagues, to whom he was universally known as 'G. B.'. In his younger days, before family life engaged so much of his time, he took a keen interest in boys' clubs. He was a man of outstandingly simple tastes, devoted to the upbringing of his family, and one who took an interest in church affairs.

He joined The Institution as an Associate Member in 1909 and was elected a Member in 1921. N. P.

ROBERT JAMES LEEDS

Maj. Robert James Leeds who was born on the 22nd December 1900 died on the 6th December 1959 at his home at Folkestone, Kent. He was educated at Southend High School and in 1917 commenced a student apprenticeship with Crompton and Co., Chelmsford, studying part-time at Chelmsford School of Science and Art. On the completion of the course he was transferred to their small-motor testing department. In 1925 he joined the Foster Engineering Co., Wimbledon, and a year later returned to Crompton Parkinson as chief assistant in the contract department.

In 1928 he became resident electrical engineer with Associated Portland Cement Manufacturers, being responsible for the electrical work involved in the reconstruction of their Wouldham and other works.

He was a keen Territorial. At the outbreak of the Second World War he commanded the Essex (Fortress) R.E.(T.A.) and was given a commission in the 469th Anti-Aircraft Company, Royal Engineers, retiring with the rank of major.

At the end of the war he returned to A.P.C.M. and was appointed assistant electrical engineer and later deputy chief electrical engineer of the engineering department, London, but unfortunately owing to ill-health had to retire in 1953, to the great regret of his colleagues and large circle of friends who held him in high esteem.

He was of a retiring and courteous nature and a conscientious worker who was always ready to give advice and help without any self-consideration. His chief hobby was his work, for which his Territorial activities provided ample scope in his earlier days. He was an enthusiastic reader of Dickens, in whose works he found great consolation in the latter days of his retirement. He is survived by his widow and a daughter.

He joined The Institution as a Graduate in 1926 and was elected an Associate in 1929, an Associate Member in 1942 and a Member in 1950. C. D. K.

JOHN MUNRO

John Munro who was born on the 13th April 1888 died on the 25th November 1959. He was educated at Hills Trust Public School, Govan, and apprenticed to Clarke Chapman and to Allan Arthur and Ure, Glasgow, studying part-time at Bellahouston Academy.

After gaining further electrical experience he joined Siemens Brothers as a chargehand in 1909, transferring as a foreman electrician to Palmers Shipbuilding, Tyneside, in 1912. Six years later he joined Furness Shipbuilding, Middlesbrough, as head foreman electrician. In 1921 he became chief mechanical and electrical engineer with the Metropolitan Tunnel and Public Works Co., working on Tube extensions for London, and in 1927 joined the City Electrical Co., London, as manager for Scotland, where he returned to take charge of the d.c. to a.c. changeover of the town of Ayr. He returned to London two years later as manager of the power maintenance department of Electrical Installations.

In 1935 he became a manager with Bower Engineering Co., London, and during the Second World War joined Clough Smith, working on airfields and ordnance factories. In 1947 he launched out on his own and formed a contracting company, Murray, Munro, London, being responsible for many important power contracts in the South of England.

Apart from his work, he was very interested and active in the Association of Supervising Electrical Engineers, representing the Association on the Institution Committee on Electrical Interference with Broadcasting and serving as national chairman in 1935–36.

His hobbies were gardening and motoring. He is survived by his widow and two sons.

He joined The Institution as a Graduate in 1924 and was elected an Associate in 1929, an Associate Member in 1934 and a Member in 1951. H. A. C.

HAROLD WILLOUGHBY RICHARDSON

Harold Willoughby Richardson, B.SC.(ENG.), who died at his home at Studland, Dorset, in November 1959 was born on the 20th December 1885. He was educated at West Kent Grammar School and commenced his engineering career in 1902 as an apprentice with the London, Brighton and South Coast Railway. This was followed by a four-year course at University College London, where he gained a B.Sc.(Eng.) degree and was awarded a senior premium for electrical engineering.

After four years, first with Marconi's and then on the staff of a consulting engineer, he joined the staff of *The Electrical Times* where he remained until the outbreak of the First World War. He served from 1914 to 1918 with the Royal Flying Corps and was engaged on wireless research.

In 1919 he joined the General Electric Co. and was appointed to the company's engineering works at Witton in charge of engineering publicity, a position which he retained until his retirement in 1946, except for a period during the Second World War, first when he was seconded to the Ministry of Supply and afterwards when he acted as materials controller for the works.

Richardson's knowledge of the company's activities, not only in the engineering field but in all other branches, was such that he was appointed editor of the *G.E.C. Journal*, which he started in 1932. He also undertook a considerable amount of writing on behalf of the company for a multitude of technical publications, at a time when technical editorial publicity was in its infancy. In this respect he was directly responsible for raising its standard from the 'advertising puff' which had become anathema to technical editors, to the well written article of a man with the high technical specialized knowledge required by the profession and which they were pleased to receive and use.

In a time of ever-growing specialization he was a man of great versatility, whose thoroughness and keen love for his profession enabled him to keep abreast in many fields of engineering and to express his knowledge clearly and in an interesting manner. He never failed to get the wholehearted co-operation both of his colleagues and of his staff; he inspired teamwork in everything he undertook.

His main interests outside his work were his church, his garden and long walks in the mountain districts of Europe. He took a great interest in the activities of the church and parish of Studland, where he lived after his retirement. He was a man of kind and gentle character, ever ready to help others in their work and in their private life. He combined wide knowledge with readiness to appreciate other people's views: all gifts which made him possess that deep understanding of engineering progress and of humanity which underlay all his work. He is survived by one son and one daughter.

He joined The Institution as a Student in 1907 and was elected an Associate Member in 1912 and a Member in 1931. H. R.

NORMAN TURNER SMITH

Norman Turner Smith who was born on the 12th January 1901 died on the 27th December 1959. He was educated at King Edward VI Grammar School and at George Dixon Secondary School, Birmingham.

He joined the Shropshire, Worcestershire and Staffordshire Electric Power Co. in 1916, serving a general apprenticeship for four years with part-time study at Suffolk Street Technical School, Birmingham, and at Smethwick Municipal Technical School. In 1920 he joined the mains department of the company at Smethwick and Oldbury. In 1925 he was appointed district representative for the Ludlow district of the company, later transferring to the Bridgnorth district.

In 1933 he joined the Kirkcudbrightshire electricity undertaking as chief engineer and manager; in 1936 he became borough electrical engineer for South Shields, transferring to Warrington Corporation in the same position in 1939, where he remained until 1948.

When the electricity supply industry was nationalized he became manager of No. 2 Sub-Area of the Merseyside and North Wales Electricity Board. A short while afterwards he went to Nova Scotia where he was appointed chief engineer of the hydroelectric undertaking.

His character and outlook were typical of those electrical engineers who were among the pioneers of the expansion and rural development of the electricity supply industry. He was a keen photographer. He is survived by his widow, two sons and a daughter.

He joined The Institution as an Associate Member in 1929 and was elected a Member in 1941. He was an Associate Member of The Institution of Mechanical Engineers. J. T. H. L.

FRANK PARKINSON SPICER

Frank Parkinson Spicer who died at Epsom on the 9th February 1960 was born on the 10th March 1879 at Godalming, Surrey, the son of Frederick Spicer, papermaker. He was educated at Bury Grammar School and apprenticed to Mather and Platt, Manchester, studying part-time at Manchester and Salford Technical Institutes. He became assistant designer and later assistant engineer with the company on the completion of his apprenticeship, but left in 1907 to set up in business on his own. He was asked to rejoin Mather and Platt in 1919 as commercial engineer and in 1921 became

manager of their Calcutta office for six years. In 1927 he joined Independent Sprinklers, for whom he carried out installations in the Argentine.

In 1937 he joined the Pyrene Co. as manager of their CO_2 division. During the Second World War he designed a prefabricated CO_2 fire-protection system which was installed in all British military tanks. He went into semi-retirement in 1950 and spent part of his time with Roberts McClean, specializing on breathing apparatus. He finally retired in 1957.

His main hobby was his car, which he was driving up to January 1960. He was renowned as a most generous and entertaining host, with a fund of good stories. A typical John Bull personality, he led a very active life, and was greatly respected, loved and appreciated for his innumerable kindly actions over a great many years. He and his widow, who survives him, celebrated happily their golden wedding anniversary in 1956.

He joined The Institution as an Associate Member in 1916 and was elected a Member in 1921. F. A. H.

HERBERT JOHN STONE

Herbert John Stone, M.C., who was born at Bristol on the 6th March 1895 died there on the 24th February 1960. He was educated at Merchant Venturers' Technical College, Bristol, and later became a pupil with Bucknell, Munro and Rogers, Bristol.

After short periods with the Newcastle upon Tyne Electric Supply Co. and the Yorkshire Electric Power Co., he volunteered within a few weeks of the outbreak of hostilities in 1914. He served first with the Royal Naval Division for two years in Gallipoli and then for three years with the Royal Engineers in France and Germany, attaining the rank of captain. He served as a junior officer on the staff of General Freyberg, V.C., and he was awarded the Military Cross and the Croix de Guerre.

In 1919 he joined the North Somerset Power Co. and in 1920 became an engineer in the contracts department of British Insulated and Helsby Cables, Prescot. For several years he was engaged in the installation of power and telephone cables and of overhead equipment for railway electrification, and was in charge for the company of their Great Indian Peninsular Railways' electrification contract. In 1929 he became manager of the company's London office. He was appointed to the Board of B.I.C.C. in 1950 as executive director (sales); in 1952 he became deputy chief executive; and in 1954 he was promoted to general manager, a position which he held until his death.

'H. J. S.', as he was affectionately called, was a man of outstanding human qualities. With his sound engineering experience and shrewd brain were coupled a warmth in human relations and an enjoyment of life which endeared him to a very wide circle of friends and colleagues. Perhaps his outstanding characteristic was courage: not only in the Services, not only in the difficulties and emergencies of business life, but also in the last two years when, after the death of his wife, and himself in increasing pain, his cheerfulness and sense of humour never deserted him.

He joined The Institution as a Student in 1914 and was elected a Graduate in 1919, an Associate in 1929, an Associate Member in 1933 and a Member in 1942. R. M. F.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint as this is the final and correct version and includes the discussion.

PAPERS

General method of digital network analysis particularly suitable for use with low-speed computers *Paper* 3259S, *Part A*

M. N. JOHN, B.SC.

THE concept of digital solutions of any of the network-analysis problems associated with the design and operation of electrical power systems is now generally appreciated. There is, however, little indication of an increasing routine use of such methods in the United Kingdom, although many types of digital computer are now available. It is suggested that this partly is due to the fact that most of the existing programmes in this field employ techniques which have been prepared by skilled programmers for use with large high-speed computers, and digital analyses consequently tend to be restricted to the realm of special studies at computing centres.

The author describes the network theory, programme details and application of a general method of digital network analysis particularly suitable for use with low-speed computers. The method has been proved using both high-speed and lower-speed computers, and the results of sample load flow and short-circuit studies are discussed.

Date of reading not yet fixed

Survey of street lighting and its future *Paper* 3260U, *Part A*

W. R. STEVENS, B.SC., *and* H. M. FERGUSON

THE accepted principles of street lighting are reviewed in conjunction with the requirements of the British Standard Code of Practice for Street Lighting.

British and oversea techniques and standards are compared and some important recent experimental work and installations described. These factors are used to assess the desirable trend of street lighting in the future.

Date of reading not yet fixed

Brushless variable-speed induction motors using phase-shift control *Paper* 3262U, *Part A*

PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., E. R. LAITHWAITE, M.SC., PH.D., J. F. EASTHAM, M.SC., *and* W. FARRER, B.SC.

THE authors describe a method of 'pole-stretching' for induction machines in which part of the stator windings is fed directly from the mains supply and part from phase-shifting transformers. Variation of the angle of phase shifting enables continuous speed control to be effected. An experimental machine is studied, the test results from which demonstrate that speed control with constant efficiency can be obtained over a speed range of 1·6 : 1.

The limitations on the range of such machines imposed by the necessary condition that the stator be discontinuous are discussed. A method of extending the speed range is explained. Machines of this type may be designed to run with a number of discrete synchronous speeds, in which case no phase-shifting transformers are necessary and speed change is effected by external switches only. The historical link between this type of machine and the spherical motor is outlined.

Date of reading not yet fixed

MONOGRAPHS

A new form of the tensor equations of electrical machines *Monograph* 378S

G. S. BROSAN, PH.D., B.SC.(ENG.)

PREVIOUS tensor methods applied to electrical engineering systems have been based on Lagrange's equations, which are not always suitable for non-holonomic systems. As a consequence, the defining equations lose much of their simplicity, and the component terms in the equations may no longer be tensors.

The author presents a new set of equations based on the principle of least curvature. These equations are suitable for both holonomic and non-holonomic systems, and their application is shown by examples.

Electric and magnetic images *Monograph* 379

P. HAMMOND, M.A.

THE method of images as applied to electrostatic, magnetostatic and electromagnetic fields is investigated. By considering the uniqueness of the field, it is shown within what limits the technique can safely be used, and rules are given for its use.

The application of the method is illustrated by a discussion of the electric field near a cylindrical cathode and the magnetic field near the end-windings of electrical machines.

R.F. spectra of waves frequency-modulated with white noise *Monograph* 380E

R. G. MEDHURST, B.SC.

ALTHOUGH comprehensive sets of curves are available giving the r.f. spectra of waves phase-modulated with band-limited white noise (simulating f.d.m. telephony signals), the corresponding problem for frequency modulation turns out to be much more intractable. In this paper the frequency-modulation problem is attacked using a method employed in an earlier paper, in conjunction with numerical devices for improving the convergence rate of very slowly converging series. The results are presented as a set of curves covering the range of modulation parameters likely to be encountered in trunk radio systems. This information is necessary for the evaluation of system bandwidth and interference due to unwanted carriers.

To bring the analysis within reasonable bounds, the minimum modulating frequency has been taken as zero. It is known that, unless the ratio between r.m.s. frequency deviation and maximum modulating frequency is large, the shape of the central portion of the spectrum changes substantially as the minimum modulating frequency departs from zero. However, for practical ranges of parameters there is evidence indicating that the shape of the spectrum tails (which is of particular importance in connection with distortion problems) is not greatly sensitive to variations in the minimum modulating frequency.

A method for the evaluation of equivalent circuit parameters of an asymmetric waveguide junction *Monograph* 381E

J. K. SINHA, M.SC., PH.D.

AS an alternative to the variational method of obtaining the equivalent circuit parameters of an asymmetric waveguide junction, the system is solved by considering that only the first few evanescent modes are excited at the junction.

The circuit parameters thus obtained agree very well with those obtained experimentally. The limitations of such a procedure are discussed.

The design of cylindrical metal-plate microwave lenses fed by non-resonant slotted waveguide arrays *Monograph* 382E

J. W. CROMPTON, M.E.

THE use of a suitably modified refractive index enables cylindrical lenses with squinting linear feeds to be designed by the usual 2-dimensional methods applicable to lenses with non-squinting feeds.

An example is given of the design of a typical lens fed by a non-resonant slotted waveguide having a 20° squint angle.

CORRESPONDENCE

REVIEW OF 'ELECTRIC-CIRCUIT THEORY'

I HAVE now been able to read most of the book by Benson and Harrison on 'Electric-circuit theory' [see December 1959 *Journal*, p. 730, and February 1960 *Journal*, p. 109] and also the book by two Assistant Professors of Electrical Engineering in the City College of New York which deals with the same subjects (Brenner and Javid, 'Analysis of electric circuits', February 1960 *Journal*, p. 118).

This latter volume of over 700 pages was described by your reviewer as providing a formal and comprehensive treatment of circuit analysis. In his review he recites some of the statements in the preface. In the first chapter, reference is made to Maxwell's equations, and it is evident that any reader who wishes to understand it must have a good knowledge of higher mathematics.

The book by Benson and Harrison starts with Ohm's law and Kirchhoff's laws governing the flow of currents in electrical circuits and discusses a large number of difficult problems, such as the design of high-pass, low-pass and band-pass filters and the effects of transient voltages and currents in supply networks, and includes a number of worked-out practical cases. Some of these examples have been used in the examination papers of the University of Sheffield but they all deal with practical problems, and the book seems to me to be one which will be very useful for electrical engineers. I am sure that many teachers of electrical engineering in both universities and colleges of advanced technology will find it of great value.

E. W. MARCHANT, D.SC., F.C.G.I.,
PAST-PRESIDENT, HONORARY MEMBER
Brook Farm, Grendon
5th April 1960 Atherstone, Warwickshire

HARWELL REACTOR COURSE FOR EUROPE

THE Harwell Reactor School is to hold a course from the 4th to 15th July 1960 for 48 technical executives from 17 member countries of the Organisation for European Economic Co-operation. These comprise the six Euratom countries, the three Scandinavian countries, Austria, Greece, Iceland, Ireland, Portugal, Spain, Switzerland and the United Kingdom.

For the first week, the course will be held at Harwell. For the second week, it will move to Durley Hall, Bournemouth, so that the lecturers during that week can be drawn from the Atomic Energy Establishment, Winfrith. The course is designed to give senior executives who have a technical background an introduction to the principles and problems of nuclear science and engineering.

Lectures given during the course will cover technical and economic aspects of nuclear energy and, in particular, problems of physics, chemistry, electronics and metallurgy involved in the construction and operation of nuclear installations.

SOME RECENT BOOKS

ELECTRICAL NOISE

D. A. BELL

LONDON: VAN NOSTRAND. 1960. 342 PP. £2 10S.

ELEKTRONISCHES RAUSCHEN—Vol. 1

H. PFEIFER

LEIPZIG: B. G. TEUBNER VERLAG. 1959. 302 PP. DM25

BOTH books cover almost the entire field in which fluctuations are important in communication, including shot-noise, thermal noise, flicker, parametric amplifiers, masers and radio astronomy. Dr. Bell's contains sections on measurement and standards, while these are promised for a second volume by Dr. Pfeifer. Both authors use the most recent mathematical techniques and report in detail much experimental work.

It is interesting to find that with so much in common two texts could be so different in their impact. Dr. Pfeifer sets out very clearly in preliminary chapters the mathematical methods and physics involved. He does not appear to have published research on fluctuations, and his name does not appear in the author index of either work. His approach is that of a mathematical physicist, and one is not aware that he has strong opinions on any particular topic.

Dr. Bell has studied fluctuations for many years, and he goes beyond the theory presented to express opinions on several topics, among them the physics underlying the flow of electrons, the philosophy of thermal fluctuations and ways of measuring fluctuations. There is occasionally a lack of clarity and sometimes room for disagreement on principles.

To illustrate lack of clarity, here are four equations from successive pages:

$V_{tot}^2 = iQR/2C$ (p. 92); $\overline{\Delta V^2} = \bar{i}eR/2C$ (p. 93)

$V^2 = Lie/2RC^2$ (p. 94); $\overline{\Delta V_{tot}^2} = \bar{i}eR/2C$ (p. 95)

The reviewer regards these all as referring to a total mean-square voltage, represented by four different symbols in only two of which the averaging process is indicated. This voltage is set up by an electron current passing through a circuit having a (parallel) capacitance C. The current appears as i and $\bar{i}$ and the electron charge as Q and e. In the first, second and fourth, R is a resistance in parallel with C, while in the third it is a resistance, usually represented by r, in series with an inductance across the capacitance. Using the relation $Rr = L/C$, this third equation can be converted to a form identical to the others. Then nothing has been learnt about the elements of the fluctuation current, which is one object of the rather lengthy discussion at this point.

The physical picture presented is sometimes unsound. For example, on p. 9 Dr. Bell remarks that the current flowing in a wire connecting two plates between which an electron passes resembles a displacement current in a dielectric. However, a displacement current sets up a potential difference growing with time, while the wire cannot support a potential difference. Consequently one could disagree with the results of argument based on this model.

Both books perform an admirable service in collecting together theory and experiment in the study of noise. An advanced student taking up research in this field would find either very useful, but he would require firm guidance through the more controversial sections of Dr. Bell's treatment.

THEORY AND DESIGN OF SMALL INDUCTION MOTORS

C. G. VEINOTT

McGRAW-HILL. 1959. 477 PP. £5 4S. 6D.

THE author is chief a.c. engineer of a large organization which manufactures many types of machine, and he has included a great deal of 'know-how' in this practical book. At the same time, fundamental theory is not neglected and the work satisfies a real need for the student of machines who is intending to pursue this aspect of electrical engineering beyond his first degree. Each chapter is followed by a comprehensive set of questions on its content. The only possible criticism here is that if the reader has sufficient background to understand the treatment he will find a lot of the questions rather trivial.

The scope covers types of small induction motor including split-phase, capacitor-start, permanent split capacitor, shaded pole, repulsion and polyphase. Approximately a quarter of the pages are devoted to design procedures, with an interesting section on the use of computers in design.

This is a volume with a modern approach which goes beyond the normal undergraduate textbook and gets down to the business of making machines. It will be of value to both students and graduates. The introduction to the subject is excellent and the text is profusely illustrated both with diagrams and with worked examples and design sheets. There is a good bibliography at the end of each chapter.

SIMPLIFIED CALCULUS

F. L. WESTWATER

ENGLISH UNIVERSITIES PRESS. 1960. 160 PP. 10S. 6D.

THIS, one of a series of elementary texts for young technicians, provides a simple introduction to differential and integral calculus suitable for students who have attained roughly O-level algebra. The author does not quote Silvanus P. Thompson's famous dictum 'what one fool can do another can', but he writes in much the same spirit. His treatment is neither so abstract as to repel his intended audience nor so purely pragmatic as to evade the problem of explaining limiting processes, and on the whole must be reckoned successful.

Clarity of exposition is perhaps best assessed by a genuine beginner. The reviewer's wife, who knows no calculus and but vaguely recalled her school algebra, was persuaded to work through the first chapter (which relates equations to graphs and introduces the derivative as a gradient); she found it more lucid than she had expected, and was inclined to recommend the book to the solitary student.

Elections and transfers

The following elections and transfers approved by the Council are effective from the 31st March 1960

ELECTIONS: 1st LIST

Graduates

BALL, Frederick Ernest
BATE, Neville Graham, B.SC.
BELL, Roger, B.SC.
BUTLER, Frank William
CORNISH, James Robert, B.A.
HENDERSON, Ian Aitken, A.R.C.S.T.
KARAGEORGIS, Ulysses
KENNEDY, Paul Gardner, B.SC., B.E.
MAXWELL, Rodford, B.SC.
MORPHET, Sydney Bentham
MOWAT, James Rennie, B.SC.
PHILLIPS, Neil Stuart
RANA, Har Bhajan Singh, A.R.C.S.T.
ROWLES, John Brian
SHICKLE, James Edward
TITTERRELL, Clifford
VERRALL, David Henry
WAGSTAFF, Derrick
WATT, Alexander Davidson, A.R.C.S.T.
WILLIAMS, John Alwyn Lewis, B.SC.

Students

ADAMS, George Howie Duncan
ADDISON, Rodney Arthur
ATHERLEY, Frank Norman Barnes
AUSTIN, Kenneth Charles Elliott, B.SC.(ENG.)
BAUGHAN, Keith Malcolm
BELL, Antony Geoffrey
BERRY, John Aitken
BRADSHAW, Michael William
CAMPBELL, Alasdair Pitt
CARELESS, John Walter
CHOWDHURY, Ujalkanti, B.SC.
DYER, Peter
EGLIN, David B.SC.
ELLIOTT, Brian Charles
EL-SHARKAWI, Emad, B.SC.
FELLINGHAM, Robert Geoffrey
FERNANDEZ, Adrian Patrick Herbert
FIELD, Richard
FISHER, David Geoffrey
FLETCHER, Charles Frederick
GRAHAM, John Hislop
GRAINGER, Charles Barry
GREENSLADE, Frederick John
HARDY, Keith
HOLMES, Kenneth William
HOOHLO, Lefa Frederick, B.SC.
HOWELLS, John William
HUNT, John
JACKSON, David
JAMES, Brian Anthony
JAMES, Peter Winston
KIMBLE, John Laurence
KNAPP, Anthony Bruce, B.SC.
KUBBA, Mahmoud Mansour
LOVATT, Godfrey Boyd
MACDONALD, John Marshall
MARTIN, Christopher Julian
MAY, Jeffrey Leonard
NODDINGS, John
NORTON, Michael Alfred
NWANKWO, Francis Agunnia
OGUNLEYE, Samuel Olutayo
OLDFIELD, Keith Arthur
OSGERBY, Michael
PEARCE, Roger Frederick
PITCAIRN, John
POSHYANANDA, Somvonk
RAM, Jackie Richard
RASHEED, Mohamed Abdul
RENCH, Alan Robert
REVINGTON, Anthony Michael
RICE, Anthony John
ROSTRON, Alan
SCOTT, James Richard
SHEPHERD, Tony Thomas William
SIVAKUMARAN, Sangarapillai
SNOWBALL, Colin
SPEAKE, William Richard Bradbury
STIRLING, Frank Blair
STRONG, Anthony Baskervyle
TANT, Michael James
TOMPSETT, Paul Francis
TUCKER, Roger Lewis Raymond
TURNBULL, Herbert Johnston
TUSTIN, Allan Edward
TYPE, Arthur Michael
WARWICK, Paul Glyn
WATSON, Nicolas John Michael
WEBB, Peter John
WESTOVER, William Alfred John
WICKRAMASURIYA, Noel Percy
WOODS, Michael

TRANSFERS: 1st LIST

Student to Graduate

ADAIR, John Frederick, B.SC.
BEHAN, Christopher George Vincent, B.ENG.
BEN-ZION, Peter Barta, ING., M.SC.
BILL, Alan James, B.ENG.
BINGHAM, James Raymond, B.SC.
BROWN, Roy William, B.SC.(ENG.)
COOK, Ian Grant, B.E.
DAILEY, Colin George Johnson, B.SC.(ENG.)
FANE DE SALIS, John Cecil Edmund, B.SC.(ENG.)
FORD, Brian John, B.SC.
FRY, Jack Peter, B.SC.(ENG.)
GOSDEN, William Lionel, B.SC.(ENG.)
GRIFFITH, John Francis
HOMER, Robert James, B.SC.
HURLEY, Michael John Mary, B.SC.TECH.
KAYE, Alan Roger, B.SC.(ENG.)
KESTER, Gerald Frederick, B.SC.
KNIGHT, Brian, DIP.TECH.(ENG.)
LAVERY, John Brian, B.SC.(ENG.)
LILL, Brian Herbert, B.SC.(ENG.)
LINDON, Peter, B.SC.(ENG.)
MAIN, John Gordon, DIP.TECH.(ENG.)
MILES, Donald Victor, B.SC.
MITCHELMORE, John Barry, B.SC.(ENG.)
MORRIS, Michael William, B.SC.TECH.
PEARSON, John Douglas, B.SC.
ROWLEY, Gordon Francis, B.SC.(ENG.)
SHARP, David, B.SC.(ENG.)
SHEPHERD, Bryan William, B.SC.(ENG.)
SPARY, Raymond Arthur, B.SC.(ENG.)
TAN, Kim Chew, B.ENG.
TILEY, Michael, B.SC.(ENG.)
WIGLEY, John Cherrington, DIP.TECH.(ENG.)
WILKINS, Brian Richard, B.SC.(ENG.)

ELECTIONS: 2nd LIST

Graduates

CUNNINGHAM, Peter William John
DRAINER, Alexander Graham, B.SC.
ELLIOT, Robert Anthony, B.SC.
FLETCHER, Charles Frederick

Graduates (continued)

GRAHAM, Frank Alfred William
GRANT, Ian Fergus, A.R.C.S.T.
HARSONO, Muljosudirdjo, B.E.
JENNINGS, Brian Anthony Tonsley, B.A.
KING, Ronald
KRISHNASWAMY, Vangal Anantha-chariar
MCKENNA, Pearse Tone Kevin, B.E.
SIMPSON, Michael Charles Stephen, B.SC.(ENG.)
SKINNER, David Robert, B.SC.
TAPPER, Edward Colin, B.SC.(ENG.)

Students

ABROOK, Maclure Alpine
AL-HAWLI, Muhammad Ali Muhammad Hani
ANDERSON, Antony Faithfull
ARMITAGE, David Anthony
BAKER, John David, B.A.
BARBER, Ronald
BARTLETT, Bryn Bayton
BIDWELL, David
BOWERS, Roy William
CHEFNEUX, Eric William
CHURCHILL, Brian Robert
CLARK, Richard Ivric
DENTON, Ian Godfrey
DUNFORD, Bryan George
DUNK, John Anthony Barrington
FORSTER, George
GIBSON, Allan Nicholas
HALL, Gerald Fryirs
HAYWARD, John
HOWARD, Peter Thomas
INNES, Alexander Esson
JAMES, Edward Stevens
JAPPY, Mitchell Jamieson
JUDGE, Michael Edward, A.R.C.S.T.
LLOYD, Ronald Henry
LØCHEN, Ragnar Capjon
MCFARLANE, Donald Miller
MCQUIRE, Adrian Frank
MELLOR, Geoffrey George
MILNE, Peter Blair
MITCHELL, Ralph Brown
MULHOLLAND, James Terence
PARKER, Derek Owen
PAYASSIS, Constantinou Roger
PECK, John Francis
PENFOLD, Anthony Roy
RUDGE, George Royston
SCOTT, Anthony William
SHROPSHALL, Peter Edward
SINGH, Raj Kishore, B.SC.(ENG.)
SMITH, Brian Michael Thomas
SWAYNE, John William Samson
TIPPETT, Michael John
VICTORIA, Antony Joseph Mangaladas
WATERS, Derek Brian
WEBB, David John
WESTON, Colin Geoffrey
WILLIAMS, Clifford James
WILLIS, Thomas Glanville
WOOD, Peter John

TRANSFERS: 2nd LIST

Student to Graduate

AHMAD, Bashir, D.F.H.
ATTERBURY, Gerald Frederick
BARTON, Michael Oliver, B.A.
BIRD, Brian Michael, B.SC.
BONWICK, William James, B.E.E.
BURCHELL, John
CORFIELD, Charles Gollan
EVANS, Robert Arthur
EVERALL, Declan Sherlock, DIP.TECH.(ENG.)
GIBSON, Hugh, B.SC.
HENNESSEY, Edward John Reid, B.SC.(ENG.)
HERRETT, Russell James, B.E.
ILLINGWORTH, Lewis, B.ENG.
JAMES, Allan Eric, B.SC.(ENG.)
MILLS, Malcolm, B.SC.
OGBORN, Raymond Henry, B.SC.
SINGLETON, Michael Peter, B.SC.(ENG.)
WILBURN, Colin Douglas, B.SC.(ENG.)

The following elections and transfers approved by the Council are effective from the 1st April 1960

ELECTIONS

Associate Members

BAINBRIDGE, Gilbert Ronald, PH.D., B.SC.
CROSTHWAITE, Peter Raymond, B.E.E.
DONOVAN, Cmdr. Andrew Sinclair, R.N.(RET.)
HAARHOFF, Felix Julian Johannes, B.SC.(ENG.)
KASINSKI, Tadeusz Adam
MADDOCK, Ieuan, B.SC.
STOKER, Maj. Richard Thomas, B.A., R.E.M.E.
VAUGHAN, Cmdr. Harold Lingard, R.N.(RET.)

Associates

MANUEL, Vincent Joseph
NASSAR, Bishara Yousef
SINCLAIR, Douglas Alan
WALLACE, Jack
WILCOX, Ernest Richard James

TRANSFERS

Associate Member to Member

CLAYTON, Robert James, M.A.
CLOUD, Thomas Harold
DRUCE, Kenneth, D.F.H.
DUCKWORTH, John Clifford, B.A.
DUNWORTH, John Vernon, M.A., PH.D.
GILL, Dennis Maxwell
GRIFFITHS, Ronald John, B.SC.(ENG.)
MARSH, Charles Donald, M.A.
MUIR, Allan Brian, B.E.
REDMOND, James
SLEIGH, Arthur Ffennell Crofton, B.SC.(ENG.)
WALTON, Patrick Hall, M.ENG.

Elections and transfers (continued)

Associate to Associate Member

KITSON, Joshua Wilson

STOCKBRIDGE, Cmdr. Edward Rupert, R.N.(RET.)

Graduate to Associate Member

APTER, John Vere, B.SC.(ENG.)
BALLAMY, Kenneth William, B.SC.(ENG.)
BARRITT, Ernest Whitehead
BATCHELOR, Leonard Frank
BINKS, Kenneth, B.SC.
BISHOP, Owen Robert Maurice
BISWAS, Parames, B.E.E.
BRASS, Alan
BROADBENT, Terence Edward, M.SC., PH.D.
BROWNRIDGE, Allan Norman
BURROWS, John William Alan, B.SC.(ENG.)
CHRISTIAN, Robert Gregory
CLARKE, Lewis Norrie, M.MECH.E., B.E.
COLDHAM, Frank, B.SC.(ENG.)
DAWSON, Alasdair Wharrie, B.SC.
DEAN, John Percival, B.SC.(ENG.)
DILWORTH, Robert Arthur
EDWARDS, Arthur Ramsay
PREWER, Reginald Austin, B.SC.(ENG.)
GOLDEN, Maurice Alfred
GRIMSDICK, Roger Brittain, B.SC.(ENG.)
HAM, Philip Arthur Lailey, B.SC.(ENG.)
HANSTEAD, Phineas David, B.SC.(ENG.)
HANKINS, Harold Charles Arthur, B.SC.TECH.
HARVEY, Walter George, B.SC.(ENG.)
HARWANKO, Eugeniusz
HAWKINS, Denis Alan, B.SC.
HEDLEY, William John
HOUGHTON, Roy, B.A.
HUGHES, Geoffrey
JAYAWANT, Bhalchandra Vinayak, PH.D., B.ENG.
JEAVONS, John Raymond
JOHNSTON, Keith Redfern, B.SC.(ENG.)
KAMATH, Hosdrug Gopalkrishna, B.SC.(ENG.)
KINGSMILL, Alec James, B.SC.
KITSON, Roy
LAWSON, Tony Eric
LEMCO, Ian, B.SC.
MCKENZIE, Archibald, B.SC.(ENG.)
NEWHALL, Sidney Noel
OSBORNE, Dennis Walker
PUTTICK, Donald Waring, B.SC.(ENG.)
RAWICZ-SZCZERBO, Janusz, B.SC.(ENG.), M.SC.
ROBINSON, Donald
ROUX, Jean Pierre, M.SC., B.SC.(ENG.)
RUSSELL, Edward John, B.SC.
SAXENA, Krishna Hari, B.SC.
SCOTT, David Murray, B.SC.(ENG.)
SCOTT, John Young, A.H.-W.C.
SIMKINS, Edward Wickens
SMITH, Penry, B.SC.
SUSSMAN, Milo, B.SC.
TODHUNTER, Ronald William, B.SC.(ENG.)
TOZER, David Francis, B.SC.(ENG.)
WADIE, Reginald Herbert
WIGGIN, Fergus Tredennick Francis, D.F.H.
WILLIAMS, Arthur Routledge
WREFORD, John Stewart

LIBRARY ACCESSIONS

BOOKS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

ANNETT, F. A. 621.876

Elevators: electric and electrohydraulic elevators, escalators, moving sidewalks, and ramps. **3rd edition***

New York and London: McGraw-Hill, 1960. pp. xi, 388. 23·5 × 16cm. £4 9s.

Describes the various types of d.c. and a.c. installations, methods of roping, governors, brake and safety devices, controllers, signalling equipment, fault location and maintenance.

CARRIER, W. H., and others 697

Modern air conditioning, heating, and ventilating. 3rd edition*

New York and London: Pitman, 1959. pp. xvi, 592. 28 × 18cm. £4

Deals with the application of existing theory to modern practice. Much of the material is data developed and used by the Carrier Corporation.

CARTER, C. F., and WILLIAMS, B. R. 338

Investment in innovation

London: Oxford University Press, 1958. pp. ix, 167. 22·5 × 14·5cm. 15s.

Investment, in this book, means spending money on industrial plant, machines and buildings. Innovation means the application of new knowledge. Thus ordinary expansion is not discussed, but the introduction of plant for new techniques, greater efficiency or reducing costs is. Reviewed in the December 1958 *Journal*, p. 678.

HARWOOD, J. J., and others (*Editors*) 62.002.3

The effects of radiation on materials

New York: Reinhold. London: Chapman and Hall, 1958. pp. v, 355. 23·5 × 16cm. £4 4s.

Consists of 11 papers giving the results of experiments on the changes produced in metals and alloys, inorganic dielectric materials, semiconductors, organic substances, etc. A bibliography with 779 entries is appended.

HUGHES, L. E. C. (*Editor*) 621.38(03)

Electronic engineer's reference book. 2nd edition

London: Heywood, 1959. pp. 1587. 19 × 12cm. £4 4s.

Covers electronic noise, radiation measurements, radiations, photocopying, r.f. heating of metals, wood and plastics, non-destructive testing, thermionic valves, c.r. tubes, transistors and magnetic amplifiers, and includes a wealth of information on automation, computing, etc. It is arranged in classified order and has a detailed index.

LESCH, G. 621.315.027.3

Lehrbuch der Hochspannungstechnik (Textbook of high-voltage engineering)

Berlin: Springer-Verlag, 1959. pp. xii, 444. 24 × 16cm. £3 7s. 8d.

Deals with electrostatic field stresses in h.v. installations and with the electric strength of equipment for power generation and distribution. This book will be reviewed in a future issue.

MARSHALL, C. A. 621.39

Communications*

London: Phoenix House. New York: Roy Publishers, 1960. pp. 64. 22 × 14·5cm. 9s. 6d.

This is one of a series of books intended to give young people an introduction to the newest discoveries in science. It deals with radiocommunication with aircraft, ships, motor vehicles, etc. by telephony and telegraphy; and with television and radar. There is a short chapter on careers.

SKROTZKI, B. G. A., and VOPAT, W. A. 621.08

Power station engineering and economy. 2nd edition of Applied energy conversion*

New York and London: McGraw-Hill, 1960. pp. x, 751. 24 × 15·5cm. £4 17s.

This was originally published in 1945 as 'Applied energy conversion'. It deals with energy processing from the raw-energy input to the rotating-shaft output of steam power, the internal-combustion engine, and water-power plants, with a section on the economics of design and operation.

UNITED TRADE PRESS LIMITED 681.2

The instrument manual. 3rd edition*

London: United Trade Press, 1960. pp. 742. 27 × 22cm. £5 5s.

Includes a wide review of modern instruments and apparatus, electrical and otherwise, for the measurement, control and recording of various quantities.

WAGNER, T. C. G. 538.551

Analytical transients

New York: John Wiley. London: Chapman and Hall, 1959. pp. xi, 202. 24 × 15cm. £3 10s.

This is not an elementary book, and in order to follow the treatment o the subject, which is based largely on Fourier's series and the Laplace transformation, knowledge of network analysis and the differential calculus is necessary. Reviewed in the November 1959 *Journal*, p. 664.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 8TH APRIL 1960

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	915	9510	9	3
£2 to <£5	2266	6237	3	7
under £2	28716	15037	18	11
		£46651	14	9

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE

ON the nomination of the Ministry of Works, the Council have appointed Mr. J. G. Jessel, ASSOCIATE MEMBER, to succeed Mr. C. E. Bedford, B.SC.(ENG.), MEMBER, on the above committee.

OVERSEA ACTIVITIES COMMITTEE

On the recommendation of the Pombay Branch Committee, the Council have appointed Mr. S. J. W. Baldwin, MEMBER, to represent the Branch on the above committee.

JOINT COMMITTEE ON PRACTICAL TRAINING IN THE ELECTRICAL ENGINEERING INDUSTRY

On the nomination of the Radio Industry Council, the Council have appointed Air Marshal Sir Raymund G. Hart, K.B.E., C.B., M.C., R.A.F., MEMBER, to serve on the above committee in place of Vice-Admiral J. W. S. Dorling, C.B., R.N., MEMBER.

B.S.I. TECHNICAL COMMITTEE ELE/46—CAPACITORS; SUB-COMMITTEE ELE/46/3—CAPACITORS FOR POWER FREQUENCY SYSTEMS

The Council have nominated Mr. C. G. Garton, MEMBER, to serve as their representative on the above committees (on which he already serves as the representative of the E.R.A.) in place of the late Mr. P. R. Coursey.

B.S.I. TECHNICAL SUB-COMMITTEE TLE/8/3—SIGNAL GENERATORS; SUB-COMMITTEE TLE/8/4—ELECTRONIC INSTRUMENTS FOR VOLTAGE MEASUREMENT

The Council have nominated Mr. D. P. E. Brown, ASSOCIATE MEMBER, to serve as their representative on the above sub-committees in place of Mr. K. H. Newhouse, MEMBER, who has asked to be relieved of service.

B.S.I. SUB-COMMITTEE USM/2/6—PREPARATION OF PART 6 OF B.S.1991 (LETTER SYMBOLS, SIGNS AND ABBREVIATIONS)

The Council have nominated Prof. M. G. Say, PH.D., M.SC., F.R.S.E., MEMBER, to serve as an additional representative with Mr. G. E. Williams, B.SC.(ENG.), MEMBER, on the above new sub-committee.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY—INDUSTRIAL ENGINEERING ADVISORY COUNCIL

The Council have nominated Mr. D. J. Mynall, B.SC.(ENG.), MEMBER, to serve as their representative on the above council.

COUNCIL NOMINATIONS—CORRECTION

IT is regretted that there was an inaccuracy in the biographical details given on p. 252 of the April 1960 *Journal* in respect of Prof. J. M. Meek, one of the Council's nominees for election to next session's Council. The dates of Prof. Meek's election or transfer to the various grades of membership should read: G. 1937, A.M. 1942, M. 1953.

CONFERENCE ON COMPONENTS AND MATERIALS USED IN ELECTRONIC ENGINEERING

12TH–17TH JUNE 1961

THE Council have approved a proposal made jointly by the Electronics and Communications Section and the Measurement and Control Section that a conference on components and materials used in electronic engineering should be held from the 12th to 17th June 1961. The conference, which is expected to attract large numbers of engineers from the United Kingdom and from many oversea countries, will be held at the Central Hall, Westminster, London S.W.1.

As recent conventions have dealt with thermionic devices, transistors and associated semiconductor devices, these topics will not be included in the scope of the conference, nor will their applications, except where a reference thereto is essential to a description of the nature of components or materials.

The scope of the conference has been divided under three main headings:

1. ***Materials***

The preparation, and the physical and electrical properties, of resistive, dielectric, magnetic, piezoelectric, ferroelectric, magnetostrictive, photosensitive, etc. materials and their application to modern components

Constructional materials such as boards for printed wiring and soldering and encapsulating materials.

Announcements to members (continued)

2. Components

Fixed and variable resistors, potentiometers, capacitors and inductors, transformers, transductors, switches, relays, plugs, sockets and contacts
Small motors and synchros
Equipment wiring, r.f. connecting cables and fuses
Potted and printed circuit components and modular structures.

Special emphasis will be placed on new techniques of measurement, reliability and the effects of extreme operating conditions.

3. Assembly techniques

Miniaturization and micro-miniaturization
Methods of automatic assembly
Wrapped and crimped connections.

Further information may be obtained from the Secretary of The Institution.

RELIABILITY OF DIGITAL COMPUTER SYSTEMS

A SERIES of discussion meetings was held on the 20th and 21st January 1960 at Savoy Place on the subject of 'Managerial and engineering aspects of reliability and maintenance of digital computer systems' (see January 1960 *Journal*, p. 10).

On the first day the British Computer Society were responsible for arranging meetings on reliability of organizational procedures, improving reliability by programming strategy, and maintenance and fault-diagnostic techniques. The second day was concerned with experience of system reliability, the influence of engineering design on reliability, and factors affecting the reliability of peripheral equipment, and was organized by The Institution.

The full text of the 19 contributions presented at the meetings, together with detailed reports of the discussions, are now available as a 72-page quarto volume, its cost being 12s. 6d. to members of a member-body of the British Conference on Automation and Computation (which includes The Institution) and 17s. 6d. to non-members. Copies can be obtained on application to the Secretary, The Institution of Electrical Engineers, Savoy Place, London W.C.2.

CORRESPONDENCE

IN view of the heavy volume of correspondence received daily at the offices of The Institution it is of the greatest assistance when members in replying to letters received from the Secretary quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

MEMBERSHIP OF LOCAL CENTRES AND SUB-CENTRES

A MEMBER whose registered address is within the area of a Centre or Sub-Centre is automatically attached to the Centre or Sub-Centre concerned, and also if he is a Student or a Graduate under the age of 28 to any Graduate and Student Section within the area. Any member who so wishes, however, may be attached to any Centre or Sub-Centre adjacent to that in which he resides, if this is more convenient to him, by making a request in writing to the Secretary of The Institution to that effect.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one local Centre or Sub-Centre to that of another arises as a result of a change of address, the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested when notifying a change of address to give their full initials, their previous address and their class of membership.

SUBSCRIPTIONS AND NATIONAL SERVICE

UNDER a recommendation approved by the Council the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary of The Institution giving the date of his call-up.

ELECTROSTATIC FORCES AND THEIR APPLICATIONS

THE Laboratoire d'Électrostatique et de Physique du Métal of the Centre National de la Recherche Scientifique is organizing an international colloquium on the physics of electrostatic forces and their applications. It will be held at Grenoble, France, from the 27th September to 1st October 1960. Particular topics to be considered include electrostatic separation, electrostatic precipitation, electrostatic application of liquids and solids, and electrostatic generators.

Further information may be obtained from the Secretary of the Organizing Committee, Prof. N.-J. Felici, Institut Fourier, Place du Doyen-Gosse, Grenoble (Isère), France.

INTERNATIONAL CONVENTION ON SEMICONDUCTOR DEVICES

THE Société des Radioélectriciens is to hold in Paris from the 20th to 25th February 1961 an international convention on semiconductor devices.

The convention will be organized under the sponsorship of the Fédération Nationale des Industries Électroniques on the occasion of the 24th exhibition (4th international exhibition) of producers of component parts, accessories, measuring instruments, radio valves and semiconductors for the electronic industries. The convention will concentrate on semiconductor devices for low-current applications.

Further information may be obtained from the Secretariat of the Société des Radioélectriciens, 10–14 avenue Pierre-Larousse, Malakoff (Seine), France.

NUMERICAL TREATMENT OF EQUATIONS

A SYMPOSIUM on the numerical treatment of ordinary differential, integral and integro-differential equations, convened by the Preparatory Committee of the International Computation Centre, will be held from the 20th to 24th September 1960 at the University of Rome.

Further information may be obtained from the co-ordinator of the symposium, Prof. A. Ghizzetti, Provisional International Computation Centre, Palazzo degli Uffici, Zona dell'EUR, Rome.

INDUSTRIAL ELECTRONICS SYMPOSIUM IN THE U.S.A.

THE ninth annual industrial electronics symposium, jointly sponsored by the Professional Group on Industrial Electronics of the Institute of Radio Engineers, and the American Institute of Electrical Engineers, is to be held at the Sheraton Cleveland Hotel, Cleveland, Ohio, on the 21st and 22nd September 1960.

The main theme of the symposium is industrial applications of electronics, stressing the application and use of new products and ideas rather than basic research. Further information is available from Mr. G. E. Hindley, Ninth Annual Industrial Electronics Symposium, Reliance Electric and Engineering Co., 24701 Euclid Avenue, Cleveland 17, Ohio, U.S.A.

ELECTRONICS CONFERENCE IN THE UNITED STATES

THE Institute of Radio Engineers announces that a national electronics conference will be held at the Sherman Hotel, Chicago, Illinois, U.S.A., from the 10th to 12th October 1960.

Topics of the conference include adaptive servomechanisms, antennae and propagation, circuit theory, communication systems, computers, information theory, instrumentation and telemetry, masers, parametric amplifiers, plasma research, radar and radio navigation, radio astronomy, solid-state circuits, space electronics, television and transistors.

AMERICAN CONFERENCE ON TECHNIQUES IN MEDICINE AND BIOLOGY

A CONFERENCE on electrical techniques in medicine and biology will be held at the Sheraton-Park Hotel, Washington, D.C., U.S.A., from the 31st October to 2nd November 1960. Its theme will be the application of electronic techniques to analytical instrumentation.

It is the 13th annual conference of its type and will be sponsored by the Joint Executive Committee in Medicine and Biology representing the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Instrument Society of America. Further information may be obtained from Mr. Lewis Winner, 152 West 42nd Street, New York 36, N.Y., U.S.A.

Forthcoming Institution events

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
S SUPPLY SECTION

May 1960

E **18** *Wednesday* Symposium on electronic-equipment reliability (field experience and methods of assessing and predicting reliability) (**at The Institution of Civil Engineers,** Great George Street, London S.W.1, at 10 a.m., 2.30 p.m. and 5.30 p.m.)

19 *Thursday* ANNUAL GENERAL MEETING *followed, at approximately 6.45 p.m., by* A. M. SPOONER, PH.D., B.SC.(ENG.). Lecture on 'Technical features of a new television studio at Wembley'*

ED **20** *Friday* PROF. F. DAHLGREN will open a discussion on 'Teaching electrical engineering in Sweden'† (at 6 p.m., tea at 5.30 p.m.)

S **21** *Saturday* Section visit to Cambridge

E **25** *Wednesday* A. F. GIBSON, PH.D., *and* G. KING, B.SC.(ENG.), will open a discussion on 'New semiconductor devices and their possible applications'‡

June 1960

23 *Thursday* Institution Conversazione (at the Royal Festival Hall, London, at 7.30 p.m.) (see April 1960 *Journal*, p. 253)

27–1 July *Monday–Friday* Summer Meeting in Scotland

* No advance information will be available
† No advance information will be available and no Press report will be permitted
‡ An abstract will be available in advance

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (APRIL 1960)

See the Journal for April 1960, p. 255

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MAY 1960)

L. ESSEN, O.B.E., D.SC., F.R.S., J. V. L. PARRY, M.SC., *and* J. McA. STEELE, B.SC.(ENG.). PAPER 3002M, AUGUST 1959 **Frequency variations of quartz oscillators and the earth's rotation in terms of the N.P.L. caesium standard** *January 1960*

P. VIGOUREUX, D.SC.(ENG.). PAPER 3242 **Electrical units and standards (Review of progress)** *May 1960*

B. B. JACOBSEN, B.SC.(ENG.). PAPER 3033E, NOVEMBER 1959 **Frequency patterns for multiple-radio-channel routes** *February 1960*

G. G. GOURIET *and* G. F. NEWELL. PAPER 3054E, OCTOBER 1959 **Quadrature network for generating vestigial-sideband signals** *March 1960*

D. P. HOWSON, M.SC., *and* PROF. D. G. TUCKER, D.SC. PAPER 3051E, JANUARY 1960 **Rectifier modulators with frequency-selective terminations** *March 1960*

PROF. D. G. TUCKER, D.SC. PAPER 3187E, JANUARY 1960 **Input impedance of rectifier modulators** *March 1960*

E. COHEN *and* R. O. JENKINS, PH.D. PAPER 3174E **Corona discharge and its application to voltage stabilization** *April 1960*

J. ALLISON, PH.D., B.SC.(ENG.). PAPER 3229E **Simple method for predicting the characteristics of tape structures** *May 1960*

J. BICKLEY, B.SC.(ENG.). PAPER 3206M **Measurement of transistor characteristic frequencies in the 20–1000 Mc/s range** *May 1960*

J. D. PEARSON, M.SC., *and* J. E. HALLETT. PAPER 3224E **Comparison of gain, bandwidth and noise figure of variable-reactance amplifiers and convertors** *May 1960*

C. CLARKE. PAPER 3158E **Study of atmospheric radio noise received in a narrow bandwidth at 11 Mc/s** *April 1960*

PART C. MONOGRAPHS (MARCH 1960)

See the Journal for March 1960, p. 183

LONDON REPORT

EDUCATION DISCUSSION CIRCLE

Four corners

A NEW look at the Ordinary National Certificate, a switch to the history and philosophy of science, a return to technicalities in generalized machine analysis and a breakaway to consider training for the professional engineer's valued assistant, the technician—such was the catholicity of interest shown by the last four meetings at Savoy Place of the Education Discussion Circle (London).

A mark for homework?

It is sometimes argued that when a dozen teachers are asked to give an opinion on some aspect of their work a dozen different answers will be forthcoming. This was completely disproved on the 20th November 1959 when Dr. T. Siklos offered his 'cock-shy' on revised draft syllabuses for the Ordinary National Certificate. He advocated a unified treatment of electrical theory instead of separation into watertight compartments of d.c. and a.c. principles, and a replacement of complicated magnetic-circuit calculations and advanced d.c. machines by electronics and elementary a.c. machines. The strong support for these proposals seemed to surprise even Dr. Siklos. On the other hand, his suggestion for including a mark for homework in the final assessment was hotly challenged and found little support.

An ultimate reference

Prof. H. Dingle left his audience on the 17th December 1959 with the feeling that 'there are more things in heaven and earth, Horatio, than are dreamt of in your philosophy.' He outlined the rise of interest in the history and philosophy of science and summed up his subject succinctly as 'the attempt to make sense out of our experience'. In spite of the esoteric nature of the subject, the discussion never flagged. The problems of the man in the street who had experienced the results of the scientific revolution of the last 50 years, the relativities of our own experience, and the need for an ultimate reference (Einstein chose the velocity of light) all received an airing.

Specific or generalized?

Mr. J. G. Henderson's plea for a generalized non-steady-state analysis of electrical machines found the audience almost equally divided on the 20th January 1960 between supporters and dissenters. The dissenters fastened on the fact that most engineers are interested in the design of a machine that is to do a specific job. The supporters argued equally strongly that generalized analysis, which is essentially the circuit analysis of electrical machines, afforded a unified approach to machine theory embracing both steady-state and transient behaviour, the latter being of increasing importance as machines are used more widely in automatic-control schemes.

Technician courses

The Institution's concern for the technician, and interest in furthering his technical development, were well illustrated by Prof. M. W. Humphrey Davies's review of courses for electrical technicians on the 23rd February 1960. He showed how the City and Guilds of London Institute had built on the foundations laid by The Institution's committee on technician training. The picture of progress painted was very encouraging: the number of entries for the intermediate examination had risen from 329 in 1957 to 784 in 1959, and syllabuses had been prepared for specialized endorsement courses to follow on the general training period culminating in the Final Certificate.

The discussion indicated that, though recruiting to these courses had been good in some parts of the country, employers were insufficiently informed about their value and were still mistakenly encouraging some employees to embark on the more academic technician course, the Ordinary National Certificate, when their mathematical standard was well below that required. Greater publicity was said to be the answer, and this could also help to resolve the problem of channelling technicians into the right courses.

Those who had had teaching experience in the technician courses laid great stress on the importance of laboratory work and the need to plan specifically for it. It was not satisfactory to take over experiments planned for the O.N.C. course. The T1 course appeared to be functioning quite well but, when it was a combined Technician–National Certificate preliminary year (ST1), the combined course needed to be something different from a watered-down version of the S1 course. Some felt that the idea of the combined year, during which the mathematically and non-mathematically inclined could be separated and directed to S2 or T2 respectively, was unwise, because those selected for the T2 course felt themselves to be failed National Certificate men. K. R. S.

DISTRICT MEETING AT READING

Lightning protection

A TALK by Dr. R. H. Golde, entitled 'The protection of high-voltage systems from lightning faults', attracted a large attendance to the meeting held on the 14th March 1960 which was presided over by Mr. J. L. Bates.

Dr. Golde outlined the mechanism of the lightning discharge to earth and quoted values for the amplitudes and waveshapes of lightning currents. From these data the surge voltages were derived which are likely to arise on overhead lines as the result of direct and indirect lightning strokes. In particular, it was shown how the occurrence of single-phase and multiphase surges is affected by the type of line construction. Methods for the reduction of the number of transient supply interruptions were discussed under the headings: overrunning earth wires, arc-suppression coils, repeater fuses and automatic reclosers.

Turning to the prevention of persistent damage to high-

voltage equipment, the speaker described the impulse spark-over characteristics of insulators and protective gaps and the impulse breakdown characteristics of solid and liquid insulation, with special reference to transformers and cables. The protective effect was examined of lengths of underground cables, spark-gaps and surge diverters, and the conditions were specified in which these various methods of protection should be applied.

The ensuing discussion was not confined to problems of high-voltage supply systems but ranged over such questions as the effect of lightning on medium-voltage and telecommunication lines, the surge strength of transformers, the protective action of lightning conductors and the geographical distribution of thunderstorms.

For putting over the subject in such an interesting and able manner and for dealing so patiently with the many questions, the appreciation of the members was ably expressed to Dr. Golde by Mr. W. F. Sands. P. J. B.

BULLETIN OF THE SECTIONS

SUPPLY

Protecting overhead lines from lightning

At an Ordinary Meeting at Savoy Place on the 4th February 1960 a special welcome was extended to the author by the President and chairman, Sir Willis Jackson, who remarked that he was always glad to see the 'next generation' coming along and making such contributions to the art as that represented in the paper to be read.

In presenting his Supply Section paper on 'The shielding of overhead lines against lightning', Dr. J. H. Gridley covered briefly the early work and ideas on lightning protection, initially of buildings and later of overhead-line systems, the relative lack of immunity of which he contrasted with the cable system with its complete screening. Consideration of the field set up when a lightning leader stroke approached a line with overrunning earth wire led to a new criterion from which, with the aid of certain assumptions, a shielding angle affording adequate protection could be calculated. [A short account of this meeting appeared in 'London report' on p. 261 of the April 1960 *Journal*; Dr. Gridley's paper was reviewed on p. 221 of the same issue.—*Editor*]

Some disappointment

The ensuing discussion was opened by Dr. J. S. Forrest, who remarked that lightning was still the greatest single cause of breakdown of overhead-line systems. The author had made an advance in the theoretical treatment of the shielding problem, but he felt some disappointment in the practical outcome, a shielding angle of 45°, which was no different from the angle given in the B.S. Code of Practice published 20 years ago.

On the simple basis of comparing the performance of lines of similar construction, for which there were well established figures for the 33kV and 132kV systems of 3·8 faults and 1 fault annually per 100 route-miles, a rate of 0·5 might be expected for the 275kV system. In fact, the value had turned out to be approximately 1·6. He wondered what views the author had on this discrepancy.

Mr. W. Casson endorsed the opener's remarks on the importance of lightning faults in high-voltage systems and said that a study, carried out for a C.I.G.R.É. committee, of actual results on lines of 225kV and above, showed how effective the earth wire is. For example, it could be shown that on a line having 16 faults annually, if unshielded, a reduction to four would result from the installation of an earth wire with a shielding angle of 45°; for an angle of 30° this figure would be reduced to two.

He emphasized the difficulties in acquiring accurate information on stroke and flashover location and said he would like to see a line constructed with a lightly insulated shielding wire provided with a spark-gap at each tower. With suitable recording equipment, much useful information could be obtained from this arrangement. He would welcome the author's views on the application of his theory to lines with two overrunning earth wires.

Meagre statistical evidence

Mr. D. F. Oakeshott said that the new criterion developed by the author was a useful contribution but queried the validity of its practical application, for which a variety of assumptions had to be made. For example, the author took the downcoming leader stroke to be vertical; one of the safest assumptions he could have made was, on the contrary, that this would never be the case! If the most common angle over the most influential portion of its path were, say, 20° from the vertical, a corresponding reduction in the shielding angle would be required, owing to the tilting of the equipotential surfaces in *their* most influential region.

Performance data from many American and Russian high-voltage lines had been analysed in relation to the effect of shielding angle, and the results indicated that for adequate shielding an angle nearer 20° was required.

Mr. G. B. Jackson directed attention to the additional role of the earth wire of screening the structure supporting it; information from certain power lines abroad indicated that for a good performance good structure screening was necessary.

Dr. R. H. Golde referred to a recent C.I.G.R.É. meeting, where it was agreed that model techniques were not effectively applicable to the problem of screening-angle determination: the need was rather for an analytical approach such as that of the author. He felt that the paper was useful in this respect, but the statistical evidence presented was too meagre. Data from the British 132kV Grid, for example, were surely available and should have been studied and presented. Conductor swing from the wind should be taken into account.

Mr. L. Csuros questioned the justification for some of the assumptions made, but agreed that a 45° angle had worked well on the 132kV Grid system. Mr. R. A. Hore, on the other hand, contended that the disappointing 275kV fault rate was evidence of shielding failures.

The author replied briefly but firmly to many of the points raised: he was unrepentant and welcomed the critical comments made in the discussion. D. F. O.

Cable dielectrics and dialecticians

A RECENT debate in the House of Lords centred on a somewhat unusual subject for that place, namely underground electric cables. Now, while their Lordships would be the first to admit to a lack of high technical knowledge of cables, they did call attention during the debate to the incontestable fact that the high-voltage underground cable of today was still insulated with impregnated paper, just as it was in 1890 when Dr. Ferranti first used the material for this purpose.

It was as though h.v.-cable design had stood still from the moment of birth, and there was an implied, but gentle, reproach that, in all those 70 years, cable makers had not found an alternative insulant more nearly comparable in cost with the medium employed in the insulation of overhead-line conductors, namely air.

The paper by Dr. B. Salvage and Mr. J. A. M. Gibbons, 'The impulse strength of impregnated-paper dielectrics as used in high-voltage cables', which was read at a meeting at Savoy Place on the 9th March 1960 under the Chairmanship of Dr. J. R. Mortlock, reminded us that, although great advances in cable techniques have in fact been made over the years, the mysteries of the mechanism of electrical breakdown in a cable have yet to be explained in a manner wholly acceptable to all cable designers. As one eminent cable maker expressed it to your reporter during the discussion when one of his own engineers came forward to speak, 'If the authors are right, this chap gets the sack!' His smile belied the threat that lay in the whispered remark, but how well it epitomized the atmosphere always to be found when a cable paper is being presented to The Institution.

Dr. Salvage presented the paper (reviewed on p. 296) in a most competent way—aided by slides of a clarity and quality not always to be found at our meetings—and then the barrage started!

A stimulating discussion

First of all came the assertion that there was nothing new in the paper, that it was merely a reiteration of work already done and recorded in the many references quoted—that indeed it but added one more to the conflicting opinions about the effect of paper density on impulse strength, but gave no new evidence.

Then came the queries as to why the authors had not used low-viscosity oil, why they had not given a general review of the subject as implied in the title of the paper, why they had drawn conclusions related to one variable when other variables were present, and so on.

One contributor after another devoted great care towards explaining fully just what were the effects of temperature and different impregnants on impulse strength; of residual moisture and temperature on loss angle: and of too much reliance on model tests on the validity of the conclusions. These praiseworthy endeavours to advance the authors' knowledge of the subject were aided in some instances by the showing of slides illustrating the results of the speakers' own impeccable work.

And so the discussion went on in a whirl of references to butt-gaps, radial interfaces, paper registration, filling media, polished electrodes, permittivity grading, metallized paper screens, paraffin jelly, and other like mysteries.

Towards the end, one contributor, in emphasizing that many factors at present unconsidered might indeed be important, said that the whole problem of the mechanism of breakdown was 'extremely complex'. That was the understatement of the evening, but it carried the promise of many more such enjoyable discussions in the years to come unless in the meantime the cable makers make the great discovery.

Dr. Salvage, in the course of a spirited reply to the discussion, said that the widely differing opinions put forward had been 'stimulating'. That just about summed it up.

D. B. I.

ELECTRONICS AND COMMUNICATIONS

V.H.F. sound broadcasting

FREQUENCY modulation on the v.h.f. bands is now making an impact on the listening public, and the paper 'V.H.F. sound broadcasting: subjective appraisal of distortion due to multipath propagation in f.m. reception', presented by Mr. R. V. Harvey of the British Broadcasting Corporation at a meeting at Savoy Place on the 4th April 1960, dealt with one of the lesser-known difficulties of the technique—audio distortion due to the existence of two paths of different length between transmitter and receiver. The theoretical aspects of the problem have been dealt with previously by Medhurst, and Mr. Harvey only outlined the causes of the trouble and the situation in which it was likely to occur.

The distortions can be evaluated objectively (Fig. 9 in the paper), but a proper appreciation of the trouble is achieved only by a demonstration. This Mr. Harvey provided, using a considerable array of expensive equipment that not only worked well with the prearranged demonstrations but actually functioned as well as one could wish for an unrehearsed experiment. The demonstrations were a disturbing reminder of the annoyance that results from the introduction of high-order harmonics having amplitudes below 1%.

Piano music is particularly susceptible to the trouble, the sound having that peculiar 'rattle' that leads most listeners to believe that the loudspeaker is at fault. It was demonstrated that amounts of delay distortion that made piano music

intolerable were quite innocuous on speech, while a 'low-fi' reproducer had marked advantages over a wide-range 'hi-fi' unit in minimizing this particular trouble. The paper is reviewed on p. 295.

Moving the cat's-whisker

All engineers have misgivings about the value of subjective judgments of performance, and in opening the discussion Mr. G. Millington commented on the choice of phrases such as 'perceptible' and 'slightly disturbing' to describe the magnitude of the distortions introduced by multipath propagation. While agreeing with the inherent weakness of subjective estimations, Mr. Harvey indicated that consistent judgments can be obtained and expanded on the meanings that were attached to the phrases. Mr. Millington's comment that when he heard the distortion on his receiver he changed the accumulator, brought considerable support from the audience, though there was a suggestion that such rank extravagance could be avoided by moving the cat's-whisker a little.

Narrowing the bandwidth of the transmission was suggested to ameliorate the trouble, as indeed it does, but only at the expense of signal/noise ratio. The distortion can be eliminated by including an adequate limiter in the receiver, a lesson that the designers of commercial receivers have obviously learnt, for Mr. Harvey reported that in the last two years domestic receivers had greatly improved in performance. This was reflected in the figures of 'listeners' complaints' provided by Mr. L. B. Turner. These had shown a steady decrease though the number of receivers in use was steadily rising and now totalled three million.

Rather surprisingly, Mr. Harvey had made no measurements using tuner units of the 'hi-fi' type though their users comprise the group most likely to be troubled by multipath distortion. The ordinary domestic receiver has such a narrow range that much of the trouble is eliminated or masked by the high level of the other distortions in the equipment.

An aerial having greater discrimination than a simple dipole is a very effective device if only two paths exist between transmitter and receiver, for when properly orientated it can reduce the amplitude of the weaker signal. This point brought an inquiry about the best method of orientating the aerial, but Mr. Harvey's suggestion that some hundreds of pounds' worth of equipment was required to ensure correct orientation caused dismay among the tartans. The gloom vanished with Mr. J. Moir's suggestion that the same result could be achieved by opening the aerial lead with a small piece of paper inserted in the input socket and then orientating the aerial on the greatly attenuated signal.

Pre-emphasis at the transmitter with de-emphasis at the receiver has been widely hailed as a cure for most forms of distortion. Mr. Page thought that the technique had been greatly overrated, though its effectiveness in dealing with multipath transmission had not been adequately recognized.

This was an excellent paper that attracted an audience which filled the Tea Room to capacity. J. M.

The hard lot of the reformer

ONE might think that such a remote and academic subject as systems of dimensions and units would only, at the best, succeed in stirring the gentlest ripple of controversy in an otherwise calm and pellucid atmosphere. Such, however, is usually far from the case. No topic outside of politics and religion appears to have such potential for arousing invective. Colleagues publicly differ, friends become estranged and chairmen, at times, almost have to restrain participants from fisticuffs. The discreetly edited versions of such discussions seldom convey the heated nature of the debate.

Against this background, the conduct of the discussion on Dr. P. Vigoureux's paper 'Development of the formulae of electromagnetism in the M.K.S. system', on the 2nd February 1960 at Savoy Place under the Chairmanship of Prof. A. Tustin, was a model of decorum. The paper is reviewed on p. 299. Mr. P. Hammond, who opened the discussion, politely welcomed the paper and, while he proceeded to disagree fiercely with some of its proposals, his ferocity was tempered with a sucking-dove quality, perhaps born of long-suffering in trying to instil any kind of system into students. Mr. C. J. Carpenter followed with a long and involved argument which frequently departed at various tangents into acute antitheses.

From such flights of dialectical fancy it was comforting to be brought back to terra firma by Dr. F. T. Chapman with a plea for getting down to brass tacks. His treatment appeared so admirably simple that one hoped that it could not be faulted but, as Dr. Vigoureux afterwards pointed out, it all depends on how many postulates you can persuade your students to swallow. Mr. D. J. E. Evans, on the other hand, was less solicitous of students' digestive powers. He would oblige graduates to be versed in *all* systems of units, although he did seek to ease their inevitable dyspepsia by means of a generalized presentation which he had devised. He also had a rational way of dealing with questions of rationalization.

The good old days

We were back to the good earth again when Mr. G. F. Freeman pleaded for a simplified version capable of being put across to ordinary students. He obviously had little use for this new-fangled M.K.S. business and expressed a nostalgic yearning for the good old-fashioned C.G.S. days. Mr. T. McGreevy did not mince his words in declaring the author's approach entirely wrong, which he illustrated with a quaint architectural analogy. Starting with twin pillars, those of the inverse-square laws in electrostatics and magnetism, supporting a lintel, Stonehenge fashion, at one point in the argument the second pillar is kicked away with an unfortunate effect on the structure.

Mr. L. Lewin was all for sweetening the M.K.S. pill with a

generous coating of C.G.S. sugar. One also gathered that some features of modern times can only be appreciated by studying the history of the Dark Ages, from whose influence we have hardly escaped. For how else can the perpetuation of the gauss and the oersted be explained? Mr. A. C. Sim, on the other hand, could only regard the C.G.S. system as a frightful horror from which any intelligent student should hasten to escape. True, perhaps, that the C.G.S. system might appear to be more palatable for beginners; but when once they wilt on its dimensionless fare, such men are dangerous.

In his reply, Dr. Vigoureux took a firm stand against those who would oblige students to study bygone systems. The various C.G.S. systems, including the Gaussian and the Heaviside, should be put in dead file and only retrieved perhaps for the purpose of some graduate writing a thesis about them. He felt it was up to the very able teachers present to devise a more detailed elementary treatment if they felt so inclined. His paper pointed the way, and he felt quite impenitent about its concepts.

The meeting closed with a vote of thanks to the author for his stimulating paper, proposed by Prof. Tustin. Your reporter, however, could not help reflecting on the hard lot of the reformer in a democracy such as ours. What hope is there for things like simplified spelling or decimal coinage when so obvious a reform as that first proposed by Giorgi in 1901 is, nearly 60 years later, still being argued about in the way we heard at this meeting? Nevertheless, 'The struggle availeth'. J. K. W.

UTILIZATION

Electricity and H_2O_2

THE paper presented on the 18th February 1960 at Savoy Place was entitled 'Electricity in the manufacture of hydrogen peroxide', the authors being Messrs. B. E. A. Vigers and R. O. Fletcher, who, in introducing their subject, referred to the variety of uses to which this particular chemical compound is put, covering, for example, such dissimilar applications as a bleaching agent for hair and as a power source in missile engineering.

They detailed the electrolytic process involved and stated that electricity can account for up to 50% of the total production cost.

As a modern factory of this nature has a maximum demand of 12 MW, and requires some 60000 lb/h of steam at the same time, one has an ideal opportunity to effect large thermal economies by utilizing private generation plant incorporating back-pressure turbines; such a factory was fully described by the authors.

They also observed that, because present tariffs are not considered suitable for this type of load, other methods are being developed which may ultimately supersede the electrolytic process in spite of its many attractive features. Their paper is reviewed on p. 300.

A Victorian touch

In opening the discussion Mr. D. B. Hogg made reference to a passage in the text of the paper which enunciated Faraday's law by stating that 'the quantity of electricity required to liberate one gramme equivalent of a substance is 96500 coulombs'. This, he said, had a lovely Victorian nostalgic touch, and, in fact, it quite cheered him up! He also pointed out that no use was made of the hydrogen and oxygen produced in the process described by the authors; he considered they could have gone to higher steam pressures, which would have enabled them to have obtained considerably more generated power than 3 MW.

Another contributor expressed the view that the growth of the electrochemical industry had been largely due to the development of the mercury-arc rectifier, but, no doubt, if such plant as the authors described were being built today the more efficient semiconductor rectifier would be used, which would save some £10000 a year.

Attention was called to the fact that, as the process involved a big load at a high load factor and could be shut down instantaneously at any time for about two hours without detriment, the supply authority ought to be able to quote attractive terms. The economics of public versus private generation were also debated, it being pointed out that a true comparison of their respective merits should be assessed over the whole life of the plant.

The cudgels were also very vigorously taken up by one speaker on behalf of the small private turbine, which, he claimed, was just as reliable and capable of taking heavy punishment as its big brother in the public-supply power stations, which, in his opinion, led a very sheltered existence.

Following replies from the authors to the numerous points raised, a well earned vote of thanks was accorded to them for their informative and stimulating paper. R. H. R.

Power rectifiers and convertors

THE paper entitled 'Some considerations in the application of power rectifiers and convertors', by Mr. J. P. McBreen, which was presented at a meeting at Savoy Place on the 10th March 1960, is of considerable interest and value, as, during the last decade, there has been not only a tremendous increase in the use of static rectifiers, coupled with the introduction of new types of such equipment, but also the opening up of new fields of application.

The author discussed the suitability and selection of semiconductor and mercury-arc rectifiers and convertors for various applications, and expressed the view that the pulse number, or number of main crests produced in the d.c. voltage per period of supply frequency, should be six or more for satisfactory commutation and heating on variable-speed machine drives or for traction motors. He also summarized the characteristics of the more widely used transformer connections. Dealing with faults, he said that the most serious

of these is a 'backfire' and he outlined the causes of this and the protective measures to be adopted to minimize its effect. A review of the paper appears on p. 298.

Biased literature

Dr. W. G. Thompson, who opened the discussion, referred to the indication given in the paper that the break-even point of efficiency between the conventional mercury-arc and the semiconductor rectifier was somewhat under 1500 volts, but pointed out that it was now possible to produce water-cooled mercury-arc rectifier equipment occupying the same, and in some cases a smaller, space than its semiconductor equivalent, which resulted in the break-even point being nearer 750 volts.

One speaker suggested that each mercury-arc rectifier should incorporate its own capacitor, in order to give leading power factor 'to cover up the sins of lagging a.c. equipment'; while another contributor, in discussing the relative qualities of selenium and germanium, made reference to 'the torrent of highly biased literature' which had emanated in the last few years with respect to the merits of these two types of semiconductor rectifier.

Finally, it was extremely interesting to learn from a representative of the British Transport Commission that the railways were already the biggest users of rectifiers in the country, and were at present engaged in buying and setting to work about a million kVA of rectifiers covering every type which had been under discussion. R. H. R.

News from the Centres

EAST MIDLAND CENTRE

Seventh Annual Ball

The ballroom of the Victoria Station Hotel, Nottingham, was filled to capacity for the Seventh Annual Ball of the Centre on the 19th February 1960. The Chairman, Mr. D. H. Parry, gave an address of welcome to the ladies and distinguished visitors—who included the senior representatives from most of the local branches of the electrical industry. Mr. O. W. Humphreys, a Vice-President, responded.

After the loyal toast, the senior Vice-Chairman of the Centre, Lt.-Col. W. E. Gill, rose to propose a special and extraordinary toast. It was the only occasion, possibly, at which a Centre had been privileged to toast the health of a Prince of the Realm, born on the day of the Annual Ball. The toast of 'the young Prince' was received with great acclamation. Loyal greetings and congratulations were sent to Her Majesty the Queen and Prince Philip, and the Chairman and those present at the Dance were later thanked in a telegram from Buckingham Palace. J. B.

East Midland Centre Annual Ball

Lt.-Col. Gill, Vice-Chairman of the Centre, presenting flowers to the ladies, with Mr. and Mrs. Humphreys on the left and Mr. and Mrs. Parry on the right

MERSEY AND NORTH WALES CENTRE

Annual General Meeting

At the Annual General Meeting at Liverpool on the 28th March 1960, the resignation was announced of the Honorary Secretary, Mr. S. Towill, who has served so well in that capacity for four years, after six years as Assistant Secretary; fortunately Mr. G. Shepherd will take over the demanding duties of this office for the 1960–61 Session. We are grateful also to Mr. D. Boyd, who has given valuable support as Assistant Secretary for two years and is being succeeded by Mr. C. E. R. Fairburn.

The session ended with the subsequent Ordinary Meeting, when Prof. Charles F. Dalziel of the University of California lectured on 'The quantitative effects of electric shock on man'. During the discussion Prof. Dalziel cited the case of a victim of electric shock being revived after nine hours' artificial respiration.

Joint meetings have been held with our two sister Institutions and with the Liverpool Engineering Society, who provided a very appropriate subject 'Vision and position: two electronic aids to marine navigation.'

Faraday Lecture

The Faraday Lecture given in the Philharmonic Hall, Liverpool, on the 10th March 1960 received the traditional enthusiastic welcome. By his approach to his subject, Prof. M. G. Say made very real the character of Michael Faraday and his influence on modern living. Nearly 6000 applications were received for the 1640 seats available, but by the willing endeavour of Prof. Say and his assistants a quart was got from the pint pot by filling it twice.

A performance in the afternoon was given almost entirely to senior pupils from the schools, and a vote of thanks was proposed to the Lecturer by Mrs. E. M. Wormald, Chairman of the Education Committee of the City Council.

Her comment was that she had never seen such an audience so quiet and attentive—a token of appreciation that was headlined in the local Press, 'Never a rustle or a shuffle'. In

the evening Mr. J. G. Parkes, Technical Director of Lever Bros. Ltd., graciously and appreciatively thanked Prof. Say on our behalf.

District Meetings

The growth of the District Meeting is surely an indication of vitality. Credit is due to the local convenors and grateful appreciation to the authors who so willingly make these meetings possible. Mr. D. St. C. Barrie has called five meetings in Warrington, including a repeat of the Chairman's Address by Mr. T. A. P. Colledge and an informal lecture on 'Plastic-insulated cables' by Mr. P. Panton, with attendances averaging over 40. Mr. E. Jacks has lectured at Wigan and Wrexham on 'Discrimination between h.r.c. fuses', and Prof. J. M. Meek discoursed at Bangor on the 3rd May 1960 on 'The mechanism of lightning'. Mr. J. M. Qualtrough presented a paper on 'Electricity supply problems' on the 22nd April 1960 at Douglas, Isle of Man.

Dinner-Dance

At the Annual Dinner-Dance held in Hulme Hall, Port Sunlight, on the 11th March 1960, Mr. and Mrs. T. A. P. Colledge received 240 members and friends. The many valuable prizes which had been generously provided were presented to the winners by Mrs. Colledge. The duties of M.C. were ably conducted by Mr. R. D. Haigh.

Mersey and North Wales Centre Dinner-Dance in Hulme Hall, Port Sunlight

Mrs. R. D. Haigh presents a bouquet to Mrs. Colledge. Mr. Colledge is on the right

L'Envoi

We shall miss loyal member Mr. W. Gilchrist on his retirement from M.A.N.W.E.B. in the near future, as he intends moving to the London area. He announced this at a recent Branch Dinner of the Electrical Contractors' Association, and when later in the mellowness of the evening the distinguished guests departed, Mr. Gilchrist left with musical honours 'Goodbye Willie, Goodbye.'

E. W. A.

NORTH-WESTERN CENTRE

A busy session

THE Chairman, Mr. F. J. Hutchinson, opened a busy session with a most informative review of trends in power-station design, and put forward an intriguing forecast of the future, in which he suggested that a 1200 MW station in this country, operating at supercritical pressure and high temperature, should be capable of generating electricity at a cost of less than ½d. per kWh.

It is a truly busy session. Apart from the monthly Centre Ordinary Meetings, the four Groups are fully active and rarely a week passes without a meeting in the Centre. This session the newly formed Education Discussion Circle has arranged three meetings, so that, including the Graduate and Student Section, by the end of the session there will have been 45 meetings of various kinds. The amount of work required to organize such a programme would be prohibitive if it were not spread over many shoulders. Each of the Groups, the Education Discussion Circle, and the Graduate and Student Section have their own Chairman, Honorary Secretary and Committee, so that nearly 100 members find an opportunity of more active work for The Institution.

Body snatching

In the 15 years since they were instituted, the Annual University Lectures have covered an astonishingly wide field, ranging from 'The nature of textiles' to 'Researches in metallurgy', and from 'Why bother about poetry?' to 'Cosmic rays'. This year, in a lecture entitled 'Resurrectionists and fellow travellers', Prof. G. A. G. Mitchell dealt with the somewhat macabre subject of 'body snatching'. After brief mention of plundering of ancient tombs and traffic in relics, the main part of the lecture dealt with the activities of those who stole bodies for anatomical purposes.

Respect for the dead caused early studies in anatomy to be carried out on the bodies of animals, but from the 13th century human dissections gradually became possible, usually on the bodies of executed criminals. In this country, until about 100 years ago, the supplies of 'subjects' obtained legally were never sufficient, and, with the growth in demand in the 18th century, there are records of graves being violated, and this trade developed until the passing of the Anatomy Act in 1832 provided for the legal supply of sufficient 'subjects.'

Traces of the trade are still to be seen in churchyards in parts of the country in the form of watch-houses, mortsafes and public vaults. Mortsafes were heavy stone or iron frames designed to make access to the coffin more difficult, and the public vaults were very strong buildings, sometimes with duplicate doors and keys, in which bodies were kept for a period before final burial. A brief article based on this lecture will be published in the *Journal* in due course.

Education Discussion Circle

Arising from discussions in 1958–59, an Education Discussion Circle has been formed, and has arranged three meetings during the current session. All three had good attendances and lively discussions, the subjects being 'Technical education

of non-National Certificate students', 'Modern applications of field plotting', and 'What fundamental principles should be illustrated in electrical engineering courses?', the last being introduced by Prof. F. C. Williams.

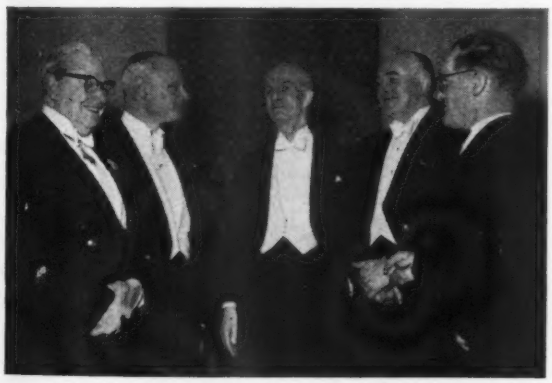
Utilization Group

The Utilization Group have for some years arranged 'laboratory' evenings at the University of Manchester when Prof. Williams and Dr. E. R. Laithwaite have given informal talks on the work done in the laboratories. The meeting this year was devoted to variable-speed induction motors, and attracted an attendance of 126.

The social event of the year is the Utilization Dinner-Dance, held annually at Sale Locarno, and this year on the 5th February. The Embassy Suite will accommodate only about 300, so that many applicants for tickets are unsuccessful, but it is considered that the intimate atmosphere would be lost if the venue were changed to accommodate more guests.

Christmas Holiday Lecture

The Christmas Holiday Lecture on 'Colour television', by Dr. R. Feinberg, was given on four occasions in the Centre: twice at Manchester, once at Salford and once at Bolton. In all cases there were crowded audiences, which indeed led to the repeat lecture at Manchester. In all some 1700 children attended, of whom a large proportion were girls. It is of interest to note that this year applications had been received from quite a number of schools which had shown no interest in the lectures in previous years, over 80 schools in the area of the Centre responding.



Annual Dinner of the North-Western Centre on the 8th March 1960

From left to right: Mr. W. K. Brasher, Mr. H. Desmond Carter, Mr. F. J. Hutchinson, Sir Willis Jackson, and Prof. F. C. Williams

Annual Dinner

The Annual Dinner was held at the Midland Hotel on Tuesday, 8th March 1960, when 460 members and guests attended, which is the maximum number the Banqueting Hall can accommodate. The President of The Institution, Sir Willis Jackson, an old member of the Centre, was present, and the chief guest was Mr. H. Desmond Carter, President of The Institution of Mechanical Engineers.

The Chairman, Mr. Hutchinson, directed attention to the presence of a member of the Centre of 59 years' standing. He then called on Mr. Desmond Carter to propose the toast of The Institution. In the course of his speech, Mr. Carter referred to the origin of The Institution of Civil Engineers, in contradistinction to military engineers, and how when George Stephenson applied for membership of that body he was turned down. His reaction was to originate The Institution of Mechanical Engineers. It is a thought that if Stephenson had been accepted by the Civils, all engineers might today be united in a single institution.

There appeared to be some doubt as to the relative sizes of The Institutions of Mechanical and of Electrical Engineers, if the claims of speakers are to be taken seriously, but all agreed that the two added up to a very imposing total.

In reply to the toast, Sir Willis expressed his pleasure in coming, as President, to the Centre of which he might be described as a member by birth, and where he started his career which had oscillated between successive half-cycles of industrial and academic activity.

Second to none

He felt that the range of educational provision and industrial activity existing together in this area placed it second to none to make major contributions to the furtherance of technical and technological education and training.

Pressing for still closer contact between the academic and industrial sides, he stressed the need for short-time courses at the most advanced level in the evolving specialist branches. This would require participation in teaching work of senior representatives from industry, as well as periods in industry for some members of teaching staffs.

The toast of 'The guests' was proposed by our Chairman, who made some interesting suggestions for closer working between the three major engineering institutions. The response was by Prof. W. I. C. Morris of the Department of Obstetrics and Gynaecology at the University of Manchester, who gave the University Lecture some years ago. Mostly in lighter vein, his remarks proved a worthy ingredient in the evening's enjoyment. The formal proceedings being complete, the great majority remained to enjoy the less formal reunion which is such a memorable feature of these annual dinners. H. G. B.

SCOTTISH CENTRE

Diamond Jubilee Dinner

THE Diamond Jubilee Dinner of the Scottish Centre was held in Edinburgh on the 17th March 1960, when a record number of members and guests, about 190, assembled under the Chairmanship of Mr. J. A. Aked. Unfortunately Mrs. Aked was temporarily indisposed, and all present joined in wishing her a quick recovery; Mrs. J. H. P. de Villiers very graciously acted as hostess for the evening. Notable among the guests was Principal-Emeritus J. Cameron Smail, who had proposed the toast of The Institution at the 50th Anniversary Dinner and who has been a member of The Institution since 1898, two years before the formation of the Scottish Centre.

To acknowledge the help The Institution has always received from the City Corporation, a special toast 'The City of Edinburgh' was introduced into the proceedings and was proposed by the Chairman; in spite of being a native of Yorkshire and a long-standing resident of Glasgow, Mr. Aked had many very kindly things to say about the City. Councillor Bruce Russell replied.

The chief guest of the evening was Mr. Harald Leslie, Q.C., who proposed the toast of The Institution in an amusing but neverthless masterly speech which held the undivided attention of the audience in such a manner that the proverbial pin could have been clearly heard to drop.

In his reply the President addressed particularly the wives of Institution members, and gave an amusingly exaggerated account of the Institution activities of ordinary members, committee members and office-bearers; but, underlying his remarks, there was a warm tribute to the very great national importance of these activities and an expression of gratitude to those who are able to carry them out.

As is customary at the Edinburgh Dinner, one of the Graduate and Student Section Chairmen, this year Mr. G. E. Woolley of South-East Scotland, spoke of the activities of the Scottish Graduate and Student Sections and was able to give a very encouraging report.

The Chairman welcomed Mr. W. K. Brasher who, in a brief speech of reply, let a cat out of a bag by mentioning that Mr. J. H. P. de Villiers was resigning from the Honorary Secretaryship of the Centre at the end of the present session; Mr. Brasher paid a warm tribute to the work for the Scottish Centre done by both Mr. and Mrs. de Villiers. The formal proceedings were concluded with a toast to the Chairman proposed by Dr. A. J. O. Cruickshank, Chairman of the North Scotland Sub-Centre.

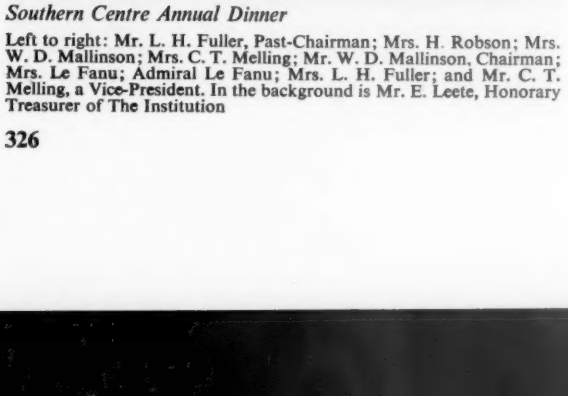
The last 1959–60 Faraday Lecture

The final presentation by Prof. M. G. Say of the 1959–60 Faraday Lecture took place in the Albert Thomson Hall of the Heriot-Watt College, Edinburgh, on the 5th April 1960. The official Scottish Centre presentation, the first of the series, had been given in Glasgow in November 1959, but, in view of the fact that the Lecturer is virtually a native of Edinburgh, the South-East Scotland Sub-Centre made special arrangements for this additional presentation.

Although being given for the 17th time, the Lecture had in no way become stale and was delivered with the same skill and enthusiasm as on the first occasion. As a result of so much practice, however, Prof. Say's assistant, Mr. G. Boal, was able to score bulls with both of his shots on the electromagnetic dart thrower.

A vote of thanks to Prof. Say was proposed by Dr. Allan, Director of the Royal Scottish Museum, and the acclamation that this was accorded showed clearly that Prof. Say had undoubtedly scored a 'bull' with the Faraday Lecture of 1959–60.

E. O. T.



Southern Centre Annual Dinner

Left to right: Mr. L. H. Fuller, Past-Chairman; Mrs. H. Robson; Mrs. W. D. Mallinson; Mrs. C. T. Melling; Mr. W. D. Mallinson, Chairman; Mrs. Le Fanu; Admiral Le Fanu; Mrs. L. H. Fuller; and Mr. C. T. Melling, a Vice-President. In the background is Mr. E. Leete, Honorary Treasurer of The Institution

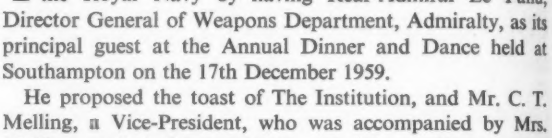
SOUTHERN CENTRE

Annual Dinner and Dance

THE Southern Centre maintained its close association with the Royal Navy by having Rear-Admiral Le Fanu, Director General of Weapons Department, Admiralty, as its principal guest at the Annual Dinner and Dance held at Southampton on the 17th December 1959.

He proposed the toast of The Institution, and Mr. C. T. Melling, a Vice-President, who was accompanied by Mrs. Melling, replied. Representatives of sister Institutions were also present.

Mr. W. D. Mallinson, the Centre Chairman, who presided, is to be congratulated on the unqualified success of the evening.



Prof. Say delivering his Faraday Lecture at Southampton

Faraday Lecture

'In all this talk about educating the public in its attitude to science it seems to have been overlooked that most of us are confused because we no longer have a clear picture of an individual, the Scientist, but a vague one of a crowd, indeed a class.'

The layman who wrote this would have had his ideas changed if he had heard this year's Faraday Lecture, for Prof. M. G. Say gave a clear picture of Michael Faraday, his work

in formulating the theory of electromagnetic induction, and its relationship to modern electrical engineering practice: he was no *persona incerta*. At Southampton, in the Guildhall, on the 15th February 1960, Prof. Say gave his Lecture to a youthful audience, and then to one less youthful, but equally enthusiastic, 3215 in all. A lapse of memory, perhaps, when demonstrating the Van de Graaff machine had a stimulating effect upon the Lecturer which he did not consider it necessary to repeat at the evening performance!

The Worshipful the Mayor of Southampton, Alderman Mrs. R. M. Stonehouse, J.P., was the Chairman. Votes of thanks to Prof. Say were proposed by a schoolgirl from the audience in the afternoon, and by Prof. Black of Southampton University in the evening, and the Mayor was thanked by Mr. Mallinson.

University research

In pursuance of a policy to present a fair number of locally produced papers at meetings, the Centre Committee invited two authors from Southampton University, Mr. R. Yorke and Mr. K. L. Morphew, to read papers on their research work, at Southampton on the 2nd March 1960.

Mr. Yorke's paper dealt with 'Investigation into loudspeaker performance'. He said that it was a matter of history that the development of the modern moving-coil loudspeaker still stemmed from Rice and Kellog's conception of 1925, and then discussed the important practical differences between subjective or listening tests and actual measurements or objective tests, and stated that most authorities agree that both are required to assess fully the performance of a particular loudspeaker. Figures and graphs were given to show that his method of measurement of cone movement was an optical-electrical one, sensitive to 0·1 micron (10^{-4}mm).

Thermal performance

Mr. Morphew in his paper outlined the wide range of engineering plant affected by temperature rise; in most cases the heat was a waste product which could cause grave complications in the design and operation of the plant.

He had studied the thermal performance of a ring of iron comparable in shape, for example, to the stator of a motor or generator. His work had included an accurate measurement of the electrical energy flowing into the ring, which was uniformly heated throughout its mass. This latter effect was achieved by forming the ring from a very closely wound coil of fine copper wire, the whole mass being impregnated.

The total heat capacity of this ring was assessed to a high degree of accuracy, and his experimental study then consisted in the thermal measurement of the heat output from the coil and its comparison with the known electrical energy to the coil; for accuracy, direct current was used. By these means the usual heating and cooling equations were brought into the investigation, and considerable question was found to exist as to how far these well accepted equations could in fact be regarded as truthful.

Mr. Morphew's figures showed that, after most careful experimentation over a long period, it was not possible to guarantee anything as close as 1% between the known heat input and the measured heat output; in fact a figure of the order of 5% would more nearly represent the best one could reasonably expect if assessing the heat input entirely from the known interior temperatures and supposedly known surface temperature.

Mr. Morphew was able to interest the audience in this apparently straightforward problem of the heating and cooling of the ring, and he indicated that not only was the steady state studied, but also the transient heating conditions took their place in his experimentation and calculation.

Striving for accuracy

The discussion was opened by Prof. L. G. A. Sims and continued by a number of other speakers until the Chairman, Mr. Mallinson, was forced to bring the discussion to a conclusion because of the lateness of the hour. Prof. Sims said that he thought the two papers concerned were excellent examples of academic research, such as universities could best carry out, in which the principles and natural laws of certain phenomena were carefully investigated and experimental measurements most scrupulously performed. There had been a large amount of successful striving for high accuracy in both Mr. Yorke's and Mr. Morphew's experiments. Prof. Sims concluded his remarks by calling attention to the great difficulty of measuring surface temperature accurately and suggested that appreciable further work might still be done on this aspect of Mr. Morphew's problem. H. R.

WEST WALES (SWANSEA) SUB-CENTRE

Visit of Sir Hamish Maclaren

One of our Vice-Presidents, in the person of Sir Hamish Duncan Maclaren, visited the Sub-Centre on the 11th February 1960. In the afternoon he attended the meeting of the Sub-Centre Committee, when members gave him a very cordial welcome. During the meeting he gave valuable information and advice on questions put to him by members concerning admission to Corporate membership of The Institution and representation of Sub-Centres on the Council.

At the Ordinary Meeting which followed, when a lecture on 'Electric shock' was given by Mr. H. Dickinson, Sir Hamish expressed his pleasure in attending the Sub-Centre and meeting members on his home ground, since he is a member of the Western Centre. He also expressed his warm appreciation of the manner in which the lecturer had dealt with his subject.

Annual Dinner-Dance

On the 25th March 1960 the Sub-Centre's Annual Dinner-Dance was held at the Langland Bay Hotel, Swansea, under the Chairmanship of Mr. J. Harley, who was accompanied by his wife. Guests and members numbered 84.

The chief guest was Col. C. J. Cellan-Jones, the Swansea surgeon and a Deputy Lieutenant of Glamorgan. In a witty speech proposing the toast of The Institution, he said he thought that many people would wonder what a medical man had to do with electrical engineering. His wartime experiences in Malta, however, brought him into close contact with electrical engineers when that island was suffering from a

severe epidemic of poliomyelitis as well as enemy air attacks. In these trying circumstances it was the electrical engineers who gave invaluable help to the doctors by making iron lungs out of almost non-existent material and thereby saving many lives. He said:

'I felt very grateful to those electrical engineers, many of whom were members of your Institution.'

Shakespeare's technical terms

The response to the toast was made by Mr. J. M. Ferguson, a member of Council, who, in a delightful speech, referred to the variations in vocabulary that have been used to describe engineers and engineering in past times and commented on

Annual Dinner-Dance of the West Wales (Swansea) Sub-Centre on the 25th March 1960

From the left are: Mr. and Mrs. T. Gill; Col. and Mrs. C. J. Cellan-Jones; Councillor Hare and Mrs. Hare, the Deputy Mayor and Mayoress of Swansea; Mr. and Mrs. J. Harley; Mr. and Mrs. J. M. Ferguson; and Mr. and Mrs. W. A. Gallon

the present-day specialization and multiplicity of technical terms, illustrating his points by Shakespeare's 'rude mechanicals' and by the person today who thinks that decibels are female telephone operators.

Mr. T. Gill, Immediate Past-Chairman of the Sub-Centre, proposed the toast of our guests. Councillor K. Hare, Deputy Mayor of Swansea, replied and said that the electrical industry had made the biggest strides in the industrial field.

We were pleased to welcome the Deputy Mayoress of Swansea; Mrs. C. J. Cellan-Jones; Mrs. J. M. Ferguson; Mr. W. A. Gallon, Chairman of The South Wales Electricity Board, and Mrs. Gallon; Mr. A. J. Dalton, Chief Commercial Engineer, The South Wales Electricity Board, and Mrs. Dalton; Mr. J. Vaughan Harries, Past-Chairman of the Utilization Section, and Mrs. Harries; and Mr. D. Stephens, the Honorary Secretary of the Western Centre, and Mrs. Stephens.

During the dance that followed, a sum of £16 17s. 6d. was collected for the Benevolent Fund. Prizes were generously donated by friends of the Sub-Centre.

The excellence of the dinner, speeches and dancing all combined to make a most enjoyable event. A. E.

News from abroad

QUEENSLAND OVERSEA COMMITTEE

Television

On the 26th February 1960, at the invitation of The Institution of Engineers, Australia, our members were able to attend a lecture by Mr. A. B. Poulsen, Divisional Engineer, Radio Installation Division, P.M.G. Department, on 'The national television transmitter, Brisbane'. This subject was of considerable topical interest, as the talk followed closely on the introduction of television services in Queensland.

The equipment involved in a modern installation as typified by station ABQ2 was described, and information was given on the manner in which programmes are handled in the studio and transferred to the transmitting tower. The lecture was plentifully illustrated by slides showing the involved circuitry developed for handling picture and sound signals to the antennae and the available reconnections to minimize interruptions to programme on receiving sets. A very brief discussion followed the lecture.

Station visit

On the 16th March there was a visit by members to station QTQ9, situated on Mt. Coottha on the outskirts of Brisbane. The party were conducted through the station by the chief engineer, Mr. Thyer, and his assistant and were able to examine at close quarters the elaborate and intricate equipment that is a necessary feature of television.

The cost of many of the items was quite staggering, which gave some indication of the expenditure necessary to set up a reliable television service. In addition to the technical side of the station, the visitors were given the opportunity of seeing the control room in operation and witnessed the presentation of a live programme for transmission to viewers.

Some 24 members took part, and, before their departure, Mr. A. S. Faulkner expressed the thanks of those present to Mr. Thyer and his assistant, and their appreciation of the opportunity of making this instructive visit. W. L. G.

UGANDA

Generation and increase

Electricity generated for Uganda during March 1960 was 20644300kWh, an increase of 11·3% over the amount generated in the same month last year. In addition, 13049000kWh were exported to Kenya.

The total increase for the first three months of this year is 17·2%.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th March to 14th April 1960 these members called at the Institution building and signed the Attendance Register of Oversea Members:

COKER, A. L. (Ipoh, Malaya)
GARNETT, W. H. (Washington, D.C.)
KEYS, H. L. (Wellington)
PRATT, J. H. (Auckland)
QUARRINGTON, J. A. (Ottawa, Ontario)
SMITH, D. H. (Lagos, Nigeria)
SUBASINGHE, H. S. (Colombo, Ceylon)
TANNER, R. H. (Belleville, Ontario)
WISE, N. (Kuching, Sarawak)